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Report

SEA-AR Range Research Assessment

Western United States

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SEA-AR is grateful to the Forest Service for granting permission to use the ecosystem map attached to the back cover. This map originally appeared in USDA-FS Handbook No. 475, entitled "Vegetation and Environmental Features of Forest and Range Ecosystems." 1977.

United States Department of Agriculture
Science and Education Administration
Agricultural Research

RANGE RESEARCH

An Assessment of Current Problems

and

A Strategy for the Future

A SUMMARY OF RANGE RESEARCH BY SEA-AR IN THE 17 WESTERN STATES

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PREFACE

Rangeland in the United States constitutes a vast resource that provides food, fiber, recreation, clean water, and scenic beauty. The Secretary of Agriculture, recognizing the importance of this resource, has issued Secretary's Memo 1999 that establishes policy for planning and implementing range programs of use and research. Further, a departmental committee on range has been established to coordinate the implementation of range policy.

This report contributes in part to SEA-AR efforts to fulfill the intent of the policy of Memo 1999 to assess and develop a coordinated plan for research. This report will serve as a guide to planning future AR range research efforts and serve as a basis for coordination with other departmental agencies.

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EXECUTIVE SUMMARY

Rangelands of the United States are comprised of several resources that contribute to meeting food, fiber, timber, water, recreation, and other needs. Collectively, rangelands are producing at less than their potential. Although in the past three decades progress has been significant in improving the condition of the range, much remains to be done. Many problems face the range manager today. Although many of these problems are unique to a specific ecosystem or location, some are common to all.

1. Water shortage (inadequate amount and undesirable seasonal distribution) limits productivity.

2. Competing biologic components reduce productivity.

3. Range management decisions are difficult because of lack of knowledge of the interdependencies among the multiple uses of the range ecosystem and lack of climatic and economic data.

4. Our knowledge of nutrient cycling in relation to soil-plant interactions, soil fertility, water supply, and animal performance is inadequate.

5. Our knowledge of optimum livestock breed and species for various ecosystems and management systems is lacking.

Innovative solutions to the above problems can follow from the application of modern technology, together with a concerted and coordinated research effort to increase our knowledge base and advance technology. The expansive, renewable range resources will contribute goods, services, and esthetic values to an evergrowing and increasingly affluent population, if management and utilization are developed that minimize the constraints of resource, economic, and social and environmental concerns.

The role of SEA-AR in a national range research program is presented, based on an evaluation of previous assessments of range research needs and a more recent assessment by SEA-AR scientists. This role is based on SEA-AR's strengths that include the expertise of its scientists, historical data base, existing research facilities, ongoing research, and capabilities to conduct long-term research, supported by basic and applied sciences.

Because range ecosystems are complex, a detailed strategy that will cover all needs and situations cannot be developed. However, as parts of a national research effort, specific needs are addressed in each of five subregional reports. Some general principles are implicit from the results of the assessment and will serve to guide planning and implementing decisions.

1. Develop strong interdisciplinary teams with adequate staff and support.

2. Develop programs directed to increasing knowledge and solving fundamental problems of the Nation's rangelands.

3. Develop cooperative research projects among teams within and among ecosystems.

4. Develop coordination of AR range research activities with Federal and State agencies and user groups to facilitate transfer of technology.

5. Build on the strength of existing programs, continue to support long-term research, and develop a reserve of knowledge through basic research.

To solve these problems interdisciplinary research teams, listed by priority, are:

Research Team	SY's Present	SY's Additional	% of Projected SY's	% Increase Present SY's	% Increase Future SY's
First Priority					
1. Grazing Management System	31.3	28	38.9	89	18.4
Second Priority					
2. Revegetation	9.5	9	12.1	95	5.9
3. Brush & Weed Control	12.2	4	10.6	33	2.6
4. Plant Improvement	18.5	5	15.4	27	3.3
5. Water Management	14.6	4	12.2	27	2.6
Third Priority					
6. Resource Evaluation Techniques	2.6	4	4.3	154	2.6
7. Insects, Diseases, Nematodes & Other Pests	4.0	1	3.3	25	0.7
8. Plant-Induced Animal Disorders	3.8	1	3.2	26	0.7
TOTALS	96.5	56	100.0		

This proposed increase in research effort is an attempt to identify SEA-AR's role in range reserch. Research is evolutionary and as such will need continuing assessment. As the resources, programs, environment, economic, and social constraints change, we will be need to reevaluate the research policies and programs to assure that the rangelands continue to benefit man. The goal of 56 additional SY's seems large as compared with the present base of 96 SY's. However, these 56 scientists spread across eight major research areas at about 20 locations would significantly help to provide the needed information to deal with issues in an increasingly complex society. The Renewable Resources Extension Act, PL 95-306, authorizes $15 million annually beginning in 1979 to address the need for technology

transfer to meet the need in five areas--forestry, range, recreation, environment, and wildlife. The major thrust areas to receive attention are grazing management systems, control of brush and weeds, and revegetation. Although much technology exists that needs to be transferred and applied, additional problems are arising each day. A concerted, coordinated effort is essential to meet these challenges and to develop new technology. The research teams listed earlier should be phased in over the next 5 years, building in part on technology needs surfaced by the increased extension activity.

INTRODUCTION

Almost half of the earth's surface is covered by rangeland, a renewable resource, a primary source of food, fiber, and contentment--the three needs basic to human life. As world population continues to expand at the annual rate of about 1.7 percent, the priority for food production remains foremost closely followed by the need for proper clothing and housing for an evergrowing population. With affluency comes a demand for more nutritious food, better living conditions, and enhanced improvement in esthetic and recreational opportunities. This Nation's and the world's rangelands can help provide basic needs in the form of goods, services, and values, as demanded by society.

Constraints. Primary constraints must be dealt with if we are to avoid unnecessary pitfalls and approach attainment of the goals for the future. Two primary constraints are a shortage of energy and a scarcity of water--both are already evident and will become more critical in the near future. Food production systems must reduce reliance upon depletable energy reserves. Nonenergy-intensive systems for food production, such as the production of red meat from rangeland, will become increasingly important. Presently, animals are the only practical means of harvesting range vegetation and converting it to food. In many parts of rangelands, water is now a major limiting factor; after the year 2000, many authorities believe that water will be the resource that most limits world food production. Development of production systems that are the most efficient in the use of this scarce resource is paramount if we are to produce the food and other products in the quantity needed by an evergrowing population.

A third constraint is an insufficient reserve technology base that comes from research and the transfer of existing technology to users. Modern technology makes it possible to handle vast quantities of data, but application to solve range problems still relies upon person-to-person contact. If the vast acreages of rangelands are to be managed intensively, the state-of-the-art technology must be transferred to the farms, ranches, and land-management offices throughout the country.

Another constraint that continues to intensify as the population grows is the increasing competition among user groups for the products from the range resources. Increasing regulations, environmental impact statements, and the multiple-use concepts place new demands on our use of existing technology and point to the need for information not now available.

As the demands for goods, services, and recreation from rangelands increase, these constraints make future range management qualitatively different from that in the past.

Toward Modern Range Management. Rangeland is a series of ecosystems, an integration of indivdual range sites. A range site is an area with distinctive physical and biological characteristics that supports a unique plant and animal community. The land manager must know the potential of

each site to realize its sustained capability. Because of the complexity of the information needed, it must be updated at frequent intervals. Land managers, both private and public, must consider the economic and cultural demands of the different users, as well as the social and economic costs and benefits.

Improved technology and technical capabilities will be available to public and private range managers including: current, remotely sensed information on animal health and performance, plant biomass, and current weather conditions; improved weather forecasting; up-to-date costs of treatments in terms of both dollars and fossil fuel energy and, perhaps, water inputs; and computerized data-base storage and functional models to transform plant, animal, soil, and environmental information into management decisions.

Rangelands of the United States are comprised of several resources that contribute to meeting food, fiber, timber, water, recreation, and other needs. Collectively, rangelands are producing forage at less than half of their potential. Production can be improved by managing range to encourage succession to a higher stage; by improving practices, such as weed and brush control, surface modification, or renovation; or by replacing existing plant species with more productive native or introduced species. Although in the past three decades progress has been significant in improving the condition of the range, much remains to be done. Many problems face the range manager today. Although many of these problems are unique to a specific ecosystem or location, some are common to all:

1. Range management decisions are diffuclt because of lack of knowledge of the interdependencies among the multiple uses of the range ecosystem, and lack of climatic and economic data.

    a. Our knowledge of the impact of range improvement practices on the environment, e.g., wildlife, erosion, water quality, is inadequate.

    b. Our knowledge of resources and of the probability of using certain environmental conditions to predict the long-term effect of management decisions is inadequate.

    c. Data on longevity of improvement practices and resulting increases in plant and animal production are lacking.

    d. Because of seasonal variations in productivity of base forage species, alternatives for complementary pastures and feedstuffs are inadequate.

    e. Adequate knowledge of the impact of wildlife on domestic livestock production and vice versa is needed.

    f. The acreages of disturbed sites (strip mines, abandoned cropland, recreational damage, etc.) are increasing, whereas our knowledge of soil, water, and plant requirements for successful revegetation to prevent deterioration and to meet local environmental laws is lacking.

g. Our knowledge of economics of alternative management opportunities is incomplete.

h. Adequate economic input and output data to adequately assess range-improvement practices for benefit of private and public managers and society in general is lacking.

i. Transfer of currently available technology is not adequate.

2. Competing biologic components reduce productivity.

a. Because of mismanagement and changing ecosystem parameters, brush and weed encroachment are problems.

b. Technically adequate and economically viable control practices for all brush species or combination of brush species are lacking.

c. Our knowledge of revegetation practices associated with various weed control practices is lacking.

d. Native and introduced species are needed that are more productive and easily established.

3. Water shortage (inadequate amount and undesirable seasonal distribution) limits productivity.

a. Our knowledge of plant-soil-fertility relationships, when soil water is limiting, is inadequate

b. Our knowledge of differences among plant species in water-use efficiency is lacking.

c. Our knowledge of moisture-harvesting techniques is inadequate.

d. Our knowledge of the effect of increasing upstream water use on downstream water supply and quality is lacking.

4. Our knowledge of nutrient cycling in relation to soil-plant interactions, soil fertility, water supply, and animal performance and production is inadequate.

a. Our knowledge of plant response to fertilizer and time and frequency of application is inadequate.

b. The effect of rangeland soil's fertility on plant productivity, animal performance, root distribution, and water use efficiency is not known.

c. Persistent productive legumes to reduce reliance on fertilizer and increase animal performance are needed.

d. Our knowledge of biological N-fixation under arid conditions is inadequate.

e. Our knowledge of fertility requirement for maximizing success of establishment of persistent species on reclaimed range sites is inadequate.

f. The role of below-ground herbivores is generally unknown and limits our development of photosynthate allocation strategies for increased range ecosystem productivity.

5. Our knowledge of optimum livestock breeds, crosses, and species for various ecosystems and management systems is lacking.

a. Adequate knowledge of cross breeding and rebreeding, calving problems, and calf performance and production is lacking.

b. Our knowledge of mixed-species management systems on forage utilization, brush and weed control, and total livestock production is lacking.

c. Our knowledge of management system for preventing or reducing animal losses from toxic plants is lacking.

STATUS OF RANGE AND RANGE RESEARCH

This review of range research was initiated in 1977 by Agricultural Research, Science and Education Administration, U.S. Department of Agriculture (SEA-AR). In this initial phase, we assessed range research and identified research needs within SEA-AR in the 17 contiguous Western States. These research needs are summarized herein. Subsequently, we will need to assess range research in the 17 Western States conducted by the total range community, including Forest Service (USFS), State Agricultural Experiment Stations (SAES), and other colleges and universities, and develop a plan for implementing a coordinated range research program. Additionally, we will need to assess the forage, pasture, and range program in the remaining States.

Characterization of Rangelands and SEA-AR Research. The first step in this assessment was to develop the following information for each of 17 SEA-AR range research locations.

(1) land resource region and area (LRA) to include land use, elevation, climate, and soils,

(2) ecosystem,

(3) potential natural vegetation and major plant species,

(4) potential seeded species,

(5) wildlife (animal) dominants,

(6) principal and related National Research Programs (NRP's),

(7) type of range research,

(8) missions, objectives, status, plans, and obstacles of research program,

(9) plant species needing improvement, plants useful for revegetation, unwanted plants, plants toxic to animals, and other range pests,

(10) estimates of land use and wildlife, and

(11) research needs.

We also determined for each of the 17 Western States information concerning:

(1) total land area,

(2) land area, percent grazed, average animal unit month (AUM) stocking rate per acre, and total AUM's for each forest-range ecosystem,

(3) condition, and present and potential stocking of each range ecosystem, and

(4) numbers and animal units (AU's) of beef cattle and stock sheep

Each SEA-AR scientist, working on rangeland was asked to complete three forms:

(1) Federal Range Research Program in SEA-AR,

(2) 1978 Range Review, and

(3) Information Available and Research Needs

Based on the information from each location and State, we divided the 17 Western States into five subregions, based on their physiography, vegetation, and management scheme. These subregions and States are:

Northern Great Plains--North and South Dakota, and Montana
Central Great Plains--Colorado, Kansas, Nebraska, and Wyoming
Southern Great Plains--Oklahoma and Texas
Southwest--Arizona, California, and New Mexico
Northwest--Idaho, Nevada, Oregon, Utah, and Washington

A comprehensive detailed report, developed for each subdivision and published separately, is summarized below.

Western Rangeland and SEA-AR Research. The range condition in each of the ecosystems is predominantly in fair to poor condition (Table 1).

Thus their full potential is not being realized. SEA-AR scientists have estimated that improving the range through the development and application of new and improved technology would more than double productivity (see footnote 2 of Table 1 for details). The current level of research effort for each ecosystem by subregion is shown in Table 2. About two-thirds of the scientific effort (64 SY) is devoted to the prairie, plains grassland, and the sagebrush ecosystems, that comprise 36 percent of the total rangelands and support 62 percent of the total livestock capacity.

The range research effort for AR scientists was divided into 12 research categories. Table 3 shows the current staff effort in these categories for each subregion. Major effort is being placed on plant improvement (17.7 SY), including germplasm collection, genetics, and breeding new plant varieties. A similar effort is placed collectively upon ecology and control of pests, insects, and disease. This research is complemented by a substantial portion of the remainder in revegetation. A minor effort is placed on complementary pastures, an important aspect of range management systems and range productivity.

The State of the Art and Science of SEA-AR Range Research. In the last 80 to 90 years, since the very inception of range research, progress has been significant in developing scientific and technical bases for range management. Current technology, such as range improvement (brush and weed control, and revegetation) leads to more forage and more stable conditions that in turn will permit greater stocking rates. Yet, although rangeland conditions have improved somewhat in the last few decades, most range scientists believe that rangeland productivity still remains at about one-half of the potential that could be achieved with current technology. Grazing strategies must be developed for each ecosystem, for various levels of range improvements, for maximizing production while maintaining or improving the resource.

While technology for controlling many undesirable plant species has been developed, unwanted plants continue to dominate millions of acres of rangelands. Emerging environmental restrictions continue to require the development of new technology to better control undesirable plants. Although improved forage plants have increased rangeland production for many sites, suitable plant materials for revegetation after mining, overgrazing, or other disturbances are still lacking in many ecosystems. Although revegetation attempts remain a risky operation on most western rangelands, because of present technology the probability of success has increased.

Range fertilization has been proven to be economical in many ecosystems. However, we know little about the full impact of fertilizer practices as a management tool along with distributing grazing and frequency of application in relation to buildup and maintenance of a "fertilizer pool." Consequently, development of suitable N-fixing plant materials compatible with native and improved plant communities is essential.

Availability of water and maximizing its use for plant production, livestock performance, grazing management, wildlife, recreation, and water supplies remain challenges.

Our understanding of energy flow and nutrient cycling of range ecosystems is only in its embryonic stages. Strategies need to be developed for optimal allocation of carbon flow. Domestic herbivores are the prime users of most rangelands; yet, in terms of energy flow, they consume less than 0.5 percent of the total energy captured by range plants. Other herbivores, particularly those belowground, have a significant, although largely unknown, effect on productivity.

RANGE RESEARCH NEEDS

Needs Expressed by Other Than SEA-AR Scientists. Within the last 5 years, several efforts have been made to develop lists or detailed descriptions of research needs on the rangelands of the Western United States.[1/] The results of eight such efforts are summarized in Table 4. Six of these summaries were developed by organizations using working groups or task forces to assemble concepts and needs. The other two consisted of general

[1/] List of sources of range research needs:

1. Agricultural Research Policy Advisory Committee. 1975. Research to Meet U.S. and World Food Needs, Kansas City, MO, July 9-11, 1975. 326 p.

2. Bureau of Land Management. 1978. Speech presented by R. Keith Miller to Western Directors Association Meeting, Aug. 9-11, 1978. (Copy of speech sent to H C Cox by R. K. Miller.)

3. Great Plains Agricultural Committee. 1976. Range Research Needs in the Great Plains. Great Plains Agricultural Council Publication 79. 60 p.

4. Klemmedson, J. O., R. D. Pieper, D. D. Dwyer, W. F. Mueggler, and M. J. Trlica. 1978. Research Needs on Western Rangelands. J. Range Manage. 31(1):4-8.

5. National Association of Conservation Districts. 1979. Pasture and Range Improvement Report. 38 p.

6. National Cattlemen's Association. 1979. Beef Cattle Research Needs and Priorities. Beef Business Bulletin, 11-2-79.

7. U.S. Department of Agriculture and National Association of State Universities and Land Grant Colleges. 1977. Range and Forage Research Needs for Red Meat Production. National Planning Committee of the Agricultural Research Policy Advisory Committee. 44 p.

8. U.S. Department of Agriculture, Association of State College and University Forestry Research Organizations, and National Association of State Universities and Land Grant Colleges. 1978. National Program of Research for Forests and Associated Rangelands, Washington, DC. U.S. Dept. Agr. ARM-H-1. 96 p.

summaries of research needs from the National Cattlemen's Association and the Bureau of Land Management. The research needs outlined by the National Association of Conservation Districts were developed from input solicited from eight other groups or organizations, where separate recommendations are also shown in Table 4. The major areas where research is needed are listed along with the appropriate subdivisions.

Needs Expressed by SEA-AR Scientists. Scientists in the 17 Western States identified eight research priorities. Table 5 lists these priorities by subregion in order of decreasing importance. In assigning priorities, SEA-AR scientists considered (1) the importance of each research problem area, (2) the amount of the current effort, and (3) the nature of the disciplines necessary to build effective research teams. The proposed mission of each of the teams suggested as a result of the survey and the suggested disciplines for scientists to comprise each research area are as follows:

Management Systems (Grazing systems, 12; Systems analysis and modeling, 3)[2/]

Mission:

Increase efficiency of red meat production and other multiple uses of rangelands by improving technology for integrated management of the interactions among soil, weather, plant, and animal resources.

Team:

Modeler (Systems Analyst, Bioengineer)
Range Scientist (Ecologist)
Economist
Range Animal Scientist
Agronomist (complementary pastures)
Plant Physiologist
Animal Ecologist
Soil Scientist
Animal Nutritionist

Revegetation (Revegetation, 7)

Mission:

Determine species adaptability to various range sites and methods of seeding to improve deteriorated or disturbed rangelands, to stabilize soils, to protect watersheds, and to improve forage resources.

[2/] Item in parentheses refers to the research need and the number of times the need (in comparable terms) was expressed by other than SEA-AR scientists (Table 4.).

Team:

Agricultural Engineer-Hydrologist
Range Scientist
Soil Scientist
Plant Physiologist
Weed Scientist

Brush and Weed Management (Brush and weed control, 6)

Mission:

Develop and evaluate reliable, economical, and safe methods for managing unwanted plants on rangelands so that the forage quantity and quality are improved, the esthetic values are enhanced, soil is protected from wind and water erosion, and animal deaths from eating poisonous plants are reduced.

Team:

Weed Scientist
Entomologist
Range Scientist
Plant Physiologist
Agricultural Engineer

Plant Improvement (Selection and breeding of range plants, 8)

Mission:

Develop superior strains of grasses, forbs, and shrubs for use on rangelands to increase yield and quality of forage, and to stabilize soils.

Team:

Cytogeneticist
Plant Breeder - Geneticist
Plant Physiologist
Range Scientist/Agronomist
Range Animal Nutritionist
Entomologist
Pathologist

Water Management (Soil and water conservation, 7)

Mission:

Develop effective practices for managing surface water and develop methods for quantifying and evaluating the effects of range management practices on water use efficiency, runoff, erosion, and sediment yield.

Team:

Engineer
Hydrologist
Range Scientist
Soil Scientist

Resource Evaluation Techniques (Identification, classification, and inventory of range ecosystems, 7)

Mission:

Develop efficient methods and techniques for measuring the primary characteristics of the range environment.

Team:

Engineer
Remote Sensing Specialist
Physicist
Ecologist
Range Scientist
Soil Scientist

Insects, Diseases, Nematodes, and Other Pests (Impact and management of insects, diseases, and nematodes, 7)

Mission:

Improve rangelands by developing practical, effective, safe, and economical means of managing major insects, diseases, nematodes, rodents, and other pests that limit productivity.

Team:

Entomologist
Nematologist
Pathologist
Range Scientist

Plant-Induced Animal Disorders (Effect and management of poisonous plants, 4)

Mission:

Identify the toxins in poisonous range plants and develop methods to manage plants and animals, neutralize the toxins if ingested or treat poisoned animals.

Team:

Animal Scientist
Veterinary Pathologist
Plant Physiologist
Range Scientist
Veterinary Toxicologist
Veterinarian
Weed Scientist

Generally, SEA-AR scientists and several groups, identified in Table 4, agree concerning which research needs are high-priority items. Undoubtedly, these needs differ among ecosystems, a fact which must be considered in implementing range-research programs. Also, no projected view of the future can forecast all potential effects. A specific insect or disease can suddenly seriously reduce productivity or cause range managers other problems. With a background of broad-based range ecosystem research, including the modeling of predicted responses to management or manipulative treatments, the anticipated effects of these catastrophic events can be better predicted and evaluated, and alternate corrective strategies developed and applied.

SEA-AR ROLE IN FUTURE RANGE RESEARCH

SEA-AR's contribution to future technology development for managing the renewable rangeland resources should be based on its strengths (expertise of its scientists, historical data base, research facilities and locations), and its ability to operate across physiographic or political boundaries. Also, SEA-AR's research can address problems on a long-term basis blending basic and applied sciences from the necessary scientific disciplines.

Its present scientific expertise should be complemented to form range ecosystem management and utilization research teams at strategic locations.

As funding permits, SEA-AR's rangeland research programs should be increased to complete all research teams that are currently in various stages of staffing.

Implementation Strategy. About 56 additional SY's are needed to address the range research problems envisioned in this report. But, where do we begin in filling the voids? In what regions or resource area are the SY needs most critical? Which of the scientific disciplines should be filled first? In what priority should the others be added? And at what rate should the SY's be added?

First Priority. To build on SEA-AR's strengths, the strategy should be to fully staff research teams at locations where scientists are productive and at locations where scientists can utilize historical data bases. These Range Management Systems research teams should be staffed so they can begin to function as soon as possible. These locations

should be fully staffed with scientists with expertise in the basic disciplines to include the soil-plant-animal-climate areas. Modelers should be added to synthesize the existing data base and to formulate working models that can be used by each team in the regions in which they are located. Other scientists should be added to complement the differing emphases of research at each location. A total of 28 additional SY's are needed to complete these research teams.

Second Priority. Four additional areas of SEA-AR research should be strengthened as soon as possible: (1) revegetation, (2) brush and weed management, (3) plant improvement, and (4) water management. The most critical need is in the area of revegetation.

Brush- and weed-management research related to revegetation problems will continue to be an important need. Additional scientists should be added to research programs with expertise in biological control of undesirable plants and both the biological control and the engineering aspects of revegetation. Plant improvement teams are functioning well at most locations, but needs exist in the areas of improving native species; adaptation of introduced species; introduction of new germplasm, particularly legumes; and continuing testing of new chemicals for efficacy and safety.

Third Priority. Some aspects of the three remaining areas of research, resource evaluation techniques, insects and other pests, and plant-induced animal disorders need strengthening--particularly identifying toxic compounds, predicting potentially hazardous introductions, and identifying the role of management systems in reducing losses from poisonous plants.

These recommendations reflect the current situation and reasonable plans for the near future. As programs change, other State and Federal agencies will initiate, expand, or decrease programs, and AR's research effort will need to be continually evaluated to ensure that it complements the total range research effort. For each of the three priority rankings, first priority should be given to locations with historical data bases that can be further analyzed and synthesized; to locations representing the most productive (currently or potentially) and widespread range types; to locations which are unique to a particular range type; and to locations where SEA-AR can share staffs with other agencies, including SAES and USFS. At locations with similar range types where SEA-AR operates more than one staff, or a SEA-AR location and another agency operate separate staffs, consideration should be given to combining staffs and forming single (multiagency) research teams.

The goal of 56 additional SY's seems large relative to the present base of 96.5 scientists. However, these additional SY's would be added over a 5-year period, or longer, to the existing program. Also, considering that these scientists would be added to eight major research areas at about 20 locations, the number per location, although small, would make a significant contribution to individual research teams and to a national range program.

Table 1. Rangeland types, areas, condition, and stocking in the 17 Western States[1/]

Ecosystem	Area (mil. acres)	Condition (%) Good	Fair	Poor	Very Poor	Grazed (%)	Stocking Rate (AUM/a)	Total Stocking[2/] (1,000 AUM's) Present	Potential
Sagebrush	129.9	12.3	36.1	35.0	16.6	89	0.182	24,641	77,770
Desert shrub	81.2	17.4	36.4	31.5	14.7	70	0.041	2,809	8,070
Southwestern shrubsteppe	43.2	10.5	14.8	41.5	33.2	92	0.084	3,775	17,140
Chaparral-mountain shrub	15.5	11.8	24.0	37.9	26.3	95	0.125	1,612	8,300
Pinyon-juniper	47.3	9.1	28.6	44.4	17.9	88	0.073	2,393	12,040
Mountain grasslands	26.9	17.5	36.2	31.2	15.1	97	0.319	16,597	29,020
Mountain meadows	3.3	32.4	38.8	21.1	7.7	79	0.613	822	4,220
Desert grasslands	24.7	8.4	24.7	50.5	16.4	93	0.091	2,998	8,220
Annual grasslands	10.2	13.2	5.0	36.7	45.1	96	1.095	10,649	64,010
Alpine	6.8	42.8	27.1	28.7	1.4	70	0.045	216	460
Shinnery	4.7	16.5	27.7	40.5	15.3	97	0.406	1,848	6,780
Texas savanna	28.4	16.4	23.5	45.9	14.2	99	0.428	16,493	43,660
Plains grasslands	175.2	14.7	34.2	39.6	11.5	98	0.294	54,325	168,560
Prairie	41.0	14.0	34.2	38.1	13.7	95	1.090	45,145	148,680
Douglas fir	38.5	--	--	--	--	52	0.049	1,000	2,000
Ponderosa pine	33.7	--	--	--	--	74	0.059	1,617	3,230
Western white pine	0.6	--	--	--	--	48	0.234	50	100
Fir-spruce	113.4	--	--	--	--	51	0.028	418	840
Hemlock-Sitka spruce	19.8	--	--	--	--	0	0.000	173	350
Larch	2.8	--	--	--	--	41	0.147	178	360
Lodgepole pine	21.2	--	--	--	--	56	0.011	527	1,050
Redwood	0.8	--	--	--	--	55	0.063	28	60
Hardwoods	39.8	--	--	--	--	56	0.059	1,222	2,440
Longleaf slash pine	0.3	--	--	--	--	96	0.200	55	110
Loblolly-shortleaf pine	5.4	--	--	--	--	37	0.011	22	40
Oak-pine	3.3	--	--	--	--	48	0.105	147	290
Oak-hickory	7.6	--	--	--	--	28	0.253	531	1,060
Oak-gum-cypress	2.8	--	--	--	--	3	2.490	191	380
Elm-ash-cottonwood	1.6	--	--	--	--	10	0.213	51	100
Wet grasslands	3.5	17.0	27.6	20.7	34.7	79	0.663	4,304	8,610
Desert	7.5	76.6	11.5	6.5	5.4	45	0.001	3	10
Total	940.9							194,840	617,960

1/ Partially obtained from and based on "An Assessment of the Forest and Range Land Situation in the United States" (Forest Service FS-345, 1980).

2/ Potential stocking was calculated by assuming that good, fair, poor, and very poor range conditions produced 80, 50, 30, and 10% respectively, of potential. Based on the ecosystems for which we had condition data, we assumed that the potential stocking for the remaining ecosystems could be approximately doubled.

Table 2. SY's in research in each ecosystem in the 17 Western States

Subregion	Ecosystem[1/] A	B	C	D	E	F	G	H	I	J	K	L	M	N
Northern Great Plains	0.8	16.0	0.8											
Central Great Plains	0.9	10.9	1.5										0.1	0.1
Southern Great Plains	5.5	10.0		2.8	5.4	1.5	0.1	0.5	0.2					
Southwest			0.3			3.2	6.4		2.4	0.8	0.1	0.1	0.2	0.4
Great Basin and Northwest	—	—	17.2	—	—	—	0.3	—	1.2	1.8	0.2	1.1	3.7	—
Total SY's	7.2	36.9	19.8	2.8	5.4	4.7	6.8	0.5	3.8	2.6	0.3	1.2	4.0	0.5
						Grand Total			96.5 SY's					

1/ Ecosystem Type: See map attached to the back cover.

A = Prairie
B = Plains Grassland
C = Sagebrush
D = Oak-Hickory
E = Texas Savana
F = Southwestern Shrubsteppe
G = Desert Grasslands
H = Shinnery
I = Desert Shrub
J = Pinyon-Juniper
K = Annual Grasslands
L = Mountain Meadows
M = Mountain Grasslands
N = Chaparral-Mountain Shrub

Table 3. SY's in each range research category in the 17 Western States

	Research Category[1/]											
Subregion	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Northern Great Plains	0	2.8	1.6	4.5	1.6	0.7	0.8	1.5	1.8	0	2.2	0.2
Central Great Plains	0.1	2.0	2.4	1.3	1.6	0.7	1.1	2.3	0.3	0	1.1	0.7
Southern Great Plains	0.4	6.5	2.8	4.6	0.9	0.8	0.2	1.1	0.8	0.4	4.2	3.2
Southwest	0.9	1.8	1.6	2.2	1.2	0	0.3	2.8	0.8	0.1	1.9	0.2
Great Basin and Northwest	1.1	4.6	1.2	4.4	0.9	0	0.6	4.2	4.7	0.4	2.3	1.1
Total SY's	2.5	17.7	9.6	17.0	6.2	2.2	3.0	11.9	8.4	0.9	11.7	5.4

Grand Total 96.5 SY's

1/ Research Categories

I = Inventory and Classification
II = Improved Plants
III = Revegetation
IV = Ecology, Damage and Control of Pests, Insects, and Disease
V = Other Manipulative Treatments
VI = Complementary Pastures
VII = Grazing Systems
VIII = Effects of Practices III-VII
IX = Livestock
X = Wildlife
XI = Basic Research
XII = Models

Table 4. Range research needs expressed by other groups and organizations

Research Needs	National Cattlemen's Association (1979)	Klemmedson et al. (1978)	Agricultural Research Policy Advisory Committee (1975)	Great Plains Agricultural Council (1976)	Bureau of Land Management (1978)	U.S. Department of Agriculture (1977)	U.S. Department of Agriculture (1978)	Pasture and Range Improvement Report-National Association Conservation Districts (1979)									Number of Times Need Expressed
								Forestry Organization	American Forage and Grassland Council	Farmer/Rancher Group	Research Groups	Society for Range Management	Soil Conservation Group	Wildlife and Environmental Groups	Other	NACD Summary	
Improvement of Rangeland for Increased Productivity and Stability	X	X	X	X		X	X		X	X	X	X	X	X	X	X	14
1. Revegetation			X	X		X	X			X	X					X	7
2. Brush and Weed Control (Management)	X		X	X							X			X		X	6
3. Impact and Management of Insects, Diseases, Nematodes	X			X		X	X			X	X					X	7
4. Impact and Management of Poisonous Plants	X			X		X					X						4
5. Burning			X	X			X							X	X		5
6. Improvement of Tillage, Fertilizer and Other Means				X			X										2
7. Economics of Improvement Practices						X	X			X		X	X				5
Identification, Classification, and Inventory of Range Ecosystems		X	X	X	X		X					X				X	7
1. Uniform Inventory Procedures			X	X								X				X	4
2. Range Suitability Criteria					X												1
3. Range Conditions and Trend Criteria																X	1
4. Site Potential		X															1
5. Remote Sensing			X				X										2
Grazing Systems	X	X	X	X	X	X	X				X	X		X	X	X	12
1. Integration of Range and Pasture	X		X	X		X	X					X				X	7
2. Energy Efficiency of Converting Forage to Protein by Animals							X									X	2
3. Nutrient Quality of Forage	X		X	X		X											4
4. Effects of Silvicultural Systems of Understory Forage							X										1
Selection and Breeding of Range Plants		X	X	X		X	X				X				X	X	8
1. Biological N-Fixation (Legumes)		X	X	X		X					X					X	6
2. Increased Efficiency for Yield, Water Use, Pest Resistance, Quality			X			X	X				X					X	5

Table 4. Range Research Needs Expressed by Other Groups and Organizations (continued)

Research Needs	National Cattlemen's Association (1979)	Klemmedson et al. (1978)	Agricultural Research Policy Advisory Committee (1975)	Great Plains Agricultural Council (1976)	Bureau of Land Management (1978)	U.S. Department of Agriculture (1977)	U.S. Department of Agriculture (1978)	Pasture and Range Improvement Report-National Association Conservation Districts (1979): Forestry Organization	American Forage and Grassland Council	Farmer/Rancher Group	Research Groups	Society for Range Management	Soil Conservation Group	Wildlife and Environmental Groups	Other	NACD Summary	Number of Times Need Expressed
Multiple Uses of Rangeland		X		X	X	X	X	X					X	X	X	X	10
1. Wildlife Benefits (Including Riparian Habitat)		X		X	X		X							X	X	X	7
2. Biology and Censusing of Wild Horses and Burros					X												1
3. Water Production, Esthetics, Recreation, etc.				X			X										2
Soil and Water Conservation		X	X		X						X			X	X	X	7
1. Improved Water Quality			X														1
2. On-site Water Management (Increased Efficiency of Water Use by Range Plants)		X	X								X						3
3. Livestock Water Supplies															X		1
4. Erosion Control															X		1
Increasing Productivity of Rangelands	X	X	X	X	X	X	X				X						8
1. Production in Relation to Phenology				X	X												2
2. Ecology and Physiology of Individual Species		X	X	X		X	X				X						6
3. Nutrient Cycling				X													1
4. Plant-Animal-Soil-Climate Interactions		X															1
5. Processing and Preservation of Range Forages	X		X														2
Importance of Rangelands (Role of Range Management)		X						X	X			X	X				5
1. Influence of Economic, Social, and Political Restraints		X															1
Improved Efficiency of Animal Production on Rangelands			X														1
Systems Analysis and Modeling			X	X		X											3
Other																	
1. Inadequate Information Dissemination and Communication								X	X	X		X	X		X		6
2. Alternative Financial Incentives for Range Improvement									X	X			X		X		4
3. Range Equipment Development			X														1

Table 5. Scientific effort (SY's) present and needed to complete research teams, by priority, in the 5 subregions of the 17 Western States

Priority	Northern Great Plains[1/]		Central Great Plains[2/]		Southern Great Plains[3/]		Southwest[4/]		Great Basin and Northwest[5/]		Total	
	SY's on Hand FY 1979	Add'l. SY's Needed	SY's on Hand FY 1979	Add'l. SY's Needed	SY's on Hand FY 1979	Add'l. SY's Needed	SY's on Hand FY 1979	Add'l. SY's Needed	SY's on Hand FY 1979	Add'l. SY's Needed	SY's on Hand FY 1979	Add'l. SY's Needed
Management Systems	7.5	7.0	4.5	4.0	4.3	6.0	4.9	6.0	10.0	5.0	31.2	28.0
Revegetation	1.5	2.0	4.0	2.0	1.5	3.0	1.9	2.0	0.7	0	9.6	9.0
Brush and Weed Management	0	0	1.0	0	6.6	2.0	2.6	2.0	2.0	0	12.2	4.0
Plant Improvement	3.8	0	2.0	0	6.7	0	1.0	4.0	5.0	1.0	18.5	5.0
Water Management	1.0	1.0	2.0	1.0	4.6	0	3.0	1.0	4.0	1.0	14.6	4.0
Resource Evaluation Techniques	0	0	0	1.0	2.2	0	0.4	2.0	0	1.0	2.6	4.0
Insects, Diseases, Nematodes, and Other Pests	4.0	1.0	0	0	0	0	0	0	0	0	4.0	1.0
Plant-Induced Animal Disorders	0	0	0	0	0	0	0	0	3.8	1.0	3.8	1.0
Total	17.8	11.0	13.5	8.0	25.9	11.0	13.8	17.0	25.5	9.0	96.5	56.0

Grand Total, present - 96.5 SY's

Grand Total, needed additionally - 56.0 SY's

1/ Northern Great Plains = Montana, North and South Dakota

2/ Central Great Plains = Colorado, Kansas, Nebraska, and Wyoming

3/ Southern Great Plains = Oklahoma and Texas

4/ Southwest = Arizona, California, and New Mexico

5/ Great Basin and Northwest = Idaho, Nevada, Oregon, Utah, and Washington

REPORTS IN THIS SERIES

Herbel, C. H., P. L. Sims, W. A. Laycock, R. J. Lorenz, R. A. Evans, K. G. Renard, SEA-AR Rangeland Scientists in the 17 Western States, R. F Barnes, and G. E. Carlson, National Program Staff Scientists. 1980. Range research, an assessment of current problems and a strategy for the future: A summary of range research by SEA-AR in the 17 western states. Agricultural Research, Science and Education Administration, U. S. Department of Agriculture. 18 pages.

Evans, R. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Great Basin and Northwest. 1980. SEA-AR range research in the Great Basin and Northwest (Idaho, Nevada, Oregon, Utah, and Washington). Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

Laycock, W. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Central Great Plains. 1980. SEA-AR range research in the Central Great Plains (Colorado, Kansas, Nebraska, and Wyoming). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Lorenz, R. J., J. R. Wight, R. J. Kartchner, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Northern Great Plains. 1980. SEA-AR range research in the Northern Great Plains (Montana, North Dakota, and South Dakota). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Renard, K. G., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southwest. 1980. SEA-AR range research in the Southwest (Arizona, California, and New Mexico). Agricultural Research, Science and Education Administration, U. S. Deparment of Agriculture.

Sims, P. L., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains. 1980. SEA-AR range research in the Southern Great Plains (Oklahoma and Texas). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

SEA-AR Range Research Assessment

Northern Great Plains

United States Department of Agriculture
Science and Education Administration
Agricultural Research

RANGE RESEARCH

An Assessment of Current Problems

and

A Strategy for the Future

NORTHERN GREAT PLAINS SUBREGION

Montana, North Dakota, South Dakota

Prepared by

R. J. Lorenz, R. J. Kartchner, J. R. Wight, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in Montana, North Dakota, and South Dakota.

CONTENTS

SEA-AR Range Research in North Dakota, South Dakota, and Montana
(Northern Great Plains States)

I. Situation

Montana and the two Dakotas make up a major portion of the region generally referred to as the northern Great Plains; however, portions of each of these three states lie outside the boundaries normally assigned to this region. Land Resource Regions, as defined by the Soil Conservation Service, USDA, (Austin, 1972) will be used to describe the land area covered by this report. A map of the Land Resource Regions and of the Land Resource Areas found in the three states is shown in Figure 1. The largest part of the three-state area is in the Plains Zone which is made up of the: Northern Great Plains Spring Wheat Region (F) and the Western Great Plains Range and Irrigation Region (G). The western one-third of Montana is in the Rocky Mountain Range and Forest Region (E), and a portion of eastern South Dakota is in the Central Feed Grain and Livestock Region (M). Rangelands in Land Resource Regions F, G, and M are generally on Capability Class III to VII land, because much of the Class III and most of the Class I and II land has been plowed for small grain production.

The climate and soils of the northern Great Plains are such that intensive farming is practiced throughout the region, and most of the ranching operations are associated with dryland wheat production. The percentage of cattle operations associated with dryland crop production enterprises varies from 57 to 100% in counties in various parts of the northern Great Plains. Climatic conditions are particularly favorable for cool-season plant growth; therefore, the northern Great Plains rangeland is very responsive to management practices including fertilization, complimentary pastures, and surface modification treatments such as contour furrowing and pitting. Due to the associated cropping operations, equipment and know-how are available for implementation of intensive management practices on rangeland. Complementary pastures of introduced species are used extensively throughout the region, and fertilization is used more or less frequently depending upon current livestock prices and fertilizer costs.

Most of the rangelands in the Land Resource Regions found in the northern Great Plains are of the mixed-prairie type composed of a mixture of cool-season and warm-season species of the midgrass and shortgrass types. The broad compatibility among species provide a continuum of vegetation types within the major plains ecosystem--Plains Grassland. This allows, and indeed requires, a wide diversity in management systems capable of success with a minimum of danger of irreparable damage to the vegetation.

A list of the ecosystems found in the three-state region is shown in Appendix A (from FRES, U.S. Forest Service, 1972). Many of these ecosystems are not found within the northern Great Plains as normally defined; however, they do occur within the three states covered by this report.

Appendix A also contains estimates of the percentage of each ecosystem in "Good", "Fair", and "Poor" range condition, the percentage of each ecosystem grazed, and the stocking rate. From these values, the present and potential total stocking have been calculated for each ecosystem for the three-state region. However, the condition, the percentage grazed, and the stocking

rate are average estimates for all of the western United States rangeland in each ecosystem; therefore, the total present and potential stocking figures need to be used cautiously due to the possibility of distorted values when applied to the specific three-state region.

The cattle and sheep numbers, and the animal units for each of the three states and the totals for the three-state region, are presented in Appendix B. These data, from the 1977 issue of Agricultural Statistics, show that over seven-million head of cattle and over one-million head of sheep graze the region. More than 5.8 million animal units were carried in the three-state region in 1977. The more than two-fold difference between the Agricultural Statistic's total animal unit figure and the present animal units, based on the AUM's from FRES shown in Appendix A, can be attributed in part to the use of two different years and to the relatively large proportion of the livestock feed provided by crop residues and by-products in this region. The complementary benefits of cropland to the range livestock industry of this region are sizeable and need to be considered in management systems. Information on big game animals is limited. The data in Appendix C is inconclusive, particularly due to no estimates for Montana.

II. Problems and Trends

The rangelands of the northern Great Plains are in a simiarid to arid region where both timeliness and quantity of available soil water either limit production or provide above-normal production. Therefore, water conservation practices and water-use-efficiency of plants are always of major concern. Extremes in temperature, precipitation, and evaporation require management with flexibility to survive the years of low production while taking advantage of the years of above-normal production. These rangelands are extremely responsive to treatment, including intensive management practices such as fertilization and surface modification. Complementary practices are extremely beneficial to most of the northern Great Plains rangelands. Shifts in species composition in response to grazing pressure, season of use, and other management practices are particularly common in the western wheatgrass-bluegramma complex.

Perodically, the relative prices for red meat and wheat are responsible for economic pressures which cause landowners to convert rangeland to cropland. During the period of 1974 through 1978, an estimated 1-million acres of seeded pastures and native range were converted to cropland in the state of Montana. South Dakota reported a net conversion of 349,000 acres for the 2-year period of 1974 to 1976; this trend has continued through 1978. Although figures are not yet available for North Dakota, the acreage is in the hundreds of thousands of acres for the past 10 years. Much of the land converted is marginal as cropland; therefore, soil erosion becomes a problem. Often, small fields are carved out of the rangeland with the intervening areas of rough terrain and rocky land too scattered and irregular to be grazed except after the cereal crop has been harvested. As in the past, much of this marginal land will need to be seeded back to grass when management problems are recognized to be greater than the questionable economic advantage. Technology for establishing perennial species on this marginal

land is inadequate to insure successful establishment, economically. Revegetation of the cropland, interspersed with rangeland, creates problems in species selection to insure compatibility for range management purposes.

As grasslands are converted to cropland, urban developments, highways, and other uses, the grazing pressure on the remaining acreage increases. This results in overuse and other management problems. Economic concerns are tremendous. Most operators know how to better manage their grasslands; but when the profit occurs, or appears to occur, on the side of poor management of the natural resource, consideration for the resource is negligible.

Brush is not a major problem on most of the northern Great Plains grasslands; however, a dicotyledonous herbacious deep-rooted perennial leafy spurge (Euphorbia esula L.) is spreading rapidly and is a major problem in rangelands. Current technology is inadequate for control of this species. The Forest Service is particularly concerned about leafy spurge on the National Grasslands. A symposium on leafy spurge was held in Bismarck, ND (June, 1979) to establish the status of the problem and a plan of action. Support of basic and applied research will be needed. Cheatgrass is increasing as a problem in some parts of the northern Great Plains as are each of several other annual species.

The current trend is to produce beef with as little fossil fuel energy input as possible. Technology is needed for introducing and managing legumes in the range for renovation of rangeland now in poor condition and for keeping palatable, nutritious forage in front of the animals during as much of the year as possible--economically and with a minimum of fossil fuel energy input.

Another important trend in the northern Great Plains is the change in policies affecting management of public lands, particularly those lands administered by the Bureau of Land Management and the Forest Service. Under the multiple-use scheme, and with pressure for the conservation and preservation of these lands, grazing allotments are, and will continue to be, decreased. This in turn creates economic hardship for the ranchers who rely on public lands for part of their operation and puts increasing demands for forage supplies on private lands. Currently, farmers and ranchers are concerned about federal legislation such as the Rare II Act and Public Law 208 which may result in restricted use of both public and private lands. These ranchers and farmers are looking to the USDA-SEA-AR for help in supplying data and information necessary to defend livestock grazing use on these lands. The BLM and FS are also in need of basic data and information needed to prepare Environmental Impact Statements, and they too look to our agency for help.

Strip mining and revegetation of mined land are important problems in the northern Great Plains. While this activity has received attention that may appear to be far beyond its relative significance, it is an important problem and will demand the time and talent of our research agency to provide technology for the reclamation process for other agencies to use in preparation of Environmental Impact Statements, as a basis for legislation related to use of the natural resources, and for regulatory agencies to use in

developing standards for determining degree of reclamation land release purposes.

An important trend in the northern Great Plains is the use of intensive management practices to develop a broader forage base. This trend and the reconversion of marginal cropland to perennial forages will result in the need to develop effective forage systems which integrate seeded, native, and fertilized pastures. The development and management of such systems will need a sizeable long-term research effort.

III. Researchable Problems and Goals

A. Research Needs:

Each SEA-AR scientist working on range or range related research in the northern Great Plains' states of Montana, North Dakota, and South Dakota was asked to evaluate range research needs and range research available in each of 12 categories. A summary of the results of the survey is presented in Appendix E_1, and a listing of research needs in priority order is presented in Appendix E_2. The results of this survey are limited in use because the objectivity of the scientists responding will generally be influenced by their interests, and only the scientist segment of those concerned with rangeland was sampled. It is, however, a starting point for further development of priority rating of range research needs.

Discussion and correspondence with range managers, including ranchers and those in government agencies, often enlightens those in research as to the urgent research needs. At the present time, these groups rate the need for research on leafy spurge as the most urgent problem in the grasslands of the northern Great Plains. The urgency is prompted by the rapid spread of this deep-rooted perennial noxious weed into grasslands. Current control methods are very costly and are generally ineffective. Total cost to the livestock industry is accelerating as acreage lost to grazing increases, and cost to the public will also increase as cost of red meat production increases due to added costs of production.

Other items of concern include:

--The native rangelands of the northern Great Plains are dominated by cool-season midgrasses. Although they are very productive, they mature in mid summer and become low in palatability and nutritional value for the rest of the season. Blue grama is the only native warm-season species of any consequence, and although it is a shortgrass species, its presence in the rangeland greatly improves animal performance in late summer and early fall. Research is needed on grazing systems involving complementary pastures or other techniques which will keep palatable, nutritious forage in front of the animals throughout the grazing season. This will require breeding and/or introduction of warm-season species, grass, or legume suitable for use in the northern Great

Plains. This improvement could increase total animal product and efficiency of production by increasing product per animal unit and/or animal product per unit of land.

--Water available for plant growth is of prime importance in the northern Great Plains. Adding one inch of water to the soil profile for use during the growing season will increase forage production by 25%. Research is needed on snow harvest, soil physical and chemical manipulation, surface modification, and other areas relating to surface hydrology, intake rate, and soil water retention under grassland. Closely related to this is the fertility aspect. Preliminary research shows that the N-cycle under perennial grasslands is very complicated and is also very responsive to management. Research is needed to characterize the N-cycle in the entire soil-plant-animal regime in the grassland system.

--Northern Great Plains grasslands generally respond to N-fertilization due to the unique combination of species and climate. Alternate sources of N need to be found, sources that require less fossil fuel input or that are more efficient after application. Little is known of the fate of N in the grassland system. Research is needed to develop an efficient, economical management system involving fertilizers. Legumes appear to be a good possibility if species and cultivars can be found or developed that are long-lived and dependable. They must become part of the permanent vegetation once they have been established in existing rangeland. The current small effort on falcata-type alfalfas shows promise and must be expanded to meet the urgent need.

--Breeding and development to provide plants with improved nutritional quality, water-use-efficiency, and persistence is needed if complementary grazing systems are to be successful. Persistence needs to include resistance to insects and disease as well as drought tolerance and competitiveness with and compatibility with other desirable species.

--There are several million acres of rangeland in western North and South Dakota and eastern Montana that are low in production due to sodic soil problems. A single deep plowing of cropland on this soil type permanently increases wheat production by an average of 9 bushels per acre. Preliminary work on grasslands shows that increases on a percentage basis may be greater than for cropland, but techniques need to be developed which will bring about the soil physical-chemical change without totally destroying the grass cover. Techniques are needed to provide an effective tillage operation to introduce and establish beneficial species to the renovated land and for management to insure long-term sustained production once renovation has been accomplished.

--Contour furrowing and other mechanical treatments have been shown to increase forage production on problem soils in southeastern Montana and in parts of the Dakotas. Mechanical methods increase infiltration rate and, if properly applied, reduce runoff which is a very effective means

of increasing production. These techniques need to be further studied and evaluated to determine site specific responses and longevity of benefits when incorporated into range management systems.

--Management of livestock on the rangeland is as important as is management of the vegetation. Animal behavior, as it relates to palatability and intake factors, is of major concern. The plant-animal, interactions as affected by complementary systems and intensive management practices, needs attention. Economy of production is greatly increased as product per animal is increased. There are potentially easy gains to be made in the animal behavior factors as they relate to animal performance.

--There is need to begin modeling of the northern Great Plains Grasslands, primarily to identify and help set priorities on research needs. With increased limitation of research resources, it is necessary to be able to identify what technology will provide the greatest increase in animal product or the greatest increase in efficiency of production. Modeling can help avoid the shotgun approach to research and help advance the art and science of range management by identifying critical areas in the soil-plant-animal-manager system.

--Requests for information on inventory techniques have been received from the North Dakota Public Service Commission and their counterparts in other states for use in determining the degree of reclamation achieved on mined rangelands. Present techniques are inadequate and too costly. The Forest Service has requested help in devleoping a new approach to range inventory. They need a technique that will consider wildlife as well as livestock needs and will fit the multiple use and interdisciplinary approaches used today. A quick and effective method is needed to analyze production of various ecosystems, integrate the results, and allow rapid changes in existing management as conditions change.

--A telephone call from BLM, Havre, Montana requested information on management of old stands of crested wheatgrass (seeded in the late 1930's on small acreages that had been carved out of the rangeland by homesteaders). These areas are too small and too numerous to fence and manage separately; therefore, they are causing management problems. Techniques for successfully introducing other species or for "regulating" the relative palatability of existing species are badly needed.

The following outline of Range Resource Management Problems in the Northern Great Plains was gleaned from the above and other sources. For simplicity, it is presented on a subject-matter basis with no attempt to prioritize.

a. Water

1. increasing supply for plant production
   land surface modification
   snow harvest
   irrigation

soil physical-chemical manipulation
intake rate on sodic soils

2. for livestock and wildlife
   - quantity
   - quality

3. watershed management
   - erosion control
   - sedimentation
   - water quality control

b. Soil

1. fertility
   - N-P-K fertilization
   - essential micronutrients
   - site interaction
   - species interaction
   - nutrient cycling
   - legumes and N fixation
   - fertilization and water-use-efficiency

2. soil physical-chemical problems
   - sodic soils
   - reclaimed mined land
   - eroded areas

c. Plants

1. seasonal growth and development (phenology)
   - palatability
   - quantity
   - quality

2. site requirements

3. response to fertilization and other intensification

4. response to management practices
   - season of use
   - intensity of use
   - type of use--grazing vs mechanical harvest

5. breeding and selection
   - characteristics needing improvement
     - nutritional quality
   - palatability
   - drought tolerance
   - insect resistance
   - disease resistance

competitiveness
seed production and quality
seedling vigor
water-use-efficiency

6. techniques for stand establishment

d. Range Animals

1. direct evaluation
   relation to plant development
   response to nutritional value
   domestic-wildlife compatibility
   metabolic disorders

2. management
   animal behavior
     in relation to palatability
     differences between species and classes
     domestic animal-wildlife relationship
     domestic species or class interaction
     grazing systems
       plant-animal effects
       complementary pastures
       integrated forage resources
       effects of intensive range practices

e. Range Pests

1. insects

2. diseases

3. nematodes

4. weeds
   leafy spurge
   annual bromes

5. rodents
   pocket gopher
   meadow vole

f. Management Systems

1. complementary practices
   special purpose pastures
   fertilization
   irrigation (very important in parts of Montana)
   use of crop residues

2. interaction of all "best" technology

on range plants and animals.

3. economics of all improved practices

4. interaction of one improved practice with others

5. effects of one improved practice on others, including overall economics

g. Modeling

1. to determine research needs

2. for management decision-making

3. for prediction

h. Remote Sensing

1. estimation of standing biomass

2. estimation of soil water content

3. species composition and density

4. disease and insect monitoring

IV. Current Research Effort

Appendices F and G summarize the distribution of scientific effort in range and related research in the northern Great Plains states of Montana, North Dakota, and South Dakota. The information in these Appendices is assembled by Research Topic Areas and Ecosystems, respectively. The total SY effort on range and range-related NRP's for FY-79 was 17.75 in the three-state area.

All but 1.7 SY of the total 17.75 SY in the three-state area are involved in research related to the Plains Grassland Ecosystem (Appendix F). Of the total 89.2 M acres of rangeland in the three-state area, 64.2 M acres occur in the Plains Grassland, 5.9 M in Sagebrush, and 2.9 M in Prairie Ecosystem (USFS, NRR-FRES, 1972). The remaining acreage is in small quantities in a number of related ecosystems.

Research effort in the three-state area is well distributed among the 12 research categories used for the survey portion of this report (Appendix G). However, two categories have no scientific effort assigned by SEA-AR in the three-state area. They are Category I, Inventory and Classification, and Category X, Wildlife. The largest scientific effort is on Category IV, Ecology, Damage, and Control of Pests, with the largest part of this input from four SY's at Bozeman.

A. Research Locations

The three-state area is fortunate to have four major SEA-AR field locations within its borders; all four are involved in range and range-related research. Located at Mandan, ND; Sidney, MT; Miles City, MT; and Bozeman, MT; programs and resources for each of these locations are unique and complementary to one another. A description of each location follows:

1. Northern Great Plains Research Laboratory, Mandan, ND

a. Mission:

The mission of the Northern Great Plains Research Laboratory, Mandan, ND is to: (1) Devise more efficient methods of managing and conserving water for croplands (irrigated and dryland) and rangelands in a limited rainfall region. (2) Determine plant growth and physiological responses of spring wheat, other cultivated crops, and range grasses to environmental parameters, principally water-temperature-nutrient relations, to develop a better understanding of the factors governing yield. (3) Develop efficient tillage, crop residue, and fertilizer management systems including minimum-till and no-till practices for summer fallow and annual cropping systems to improve seed zone and plant growth environments while conserving water and energy (fuel), and minimizing soil losses to erosion. (4) Devise efficient methods of managing fertilizers and naturally occurring nutrients, including biological N-production, to increase forage and crop production of rangeland and cultivated dryland and irrigated soils without environmental degradation. (5) Identify germplasm and develop superior cultivars of grass, legume, and tree species while concurrently developing management practices based on an assessment of the physiological and pathological limitations to optimum grassland and field windbreak production and use. (6) Develop cost-efficient intensive grazing management systems capable of increasing productivity of forage and red meat without environmental degradation or loss of our nation's soil, water, and range resources. (7) Develop the criteria needed to manage, reclaim, and/or restore productivity of saline, sodic, and severely disturbed lands in the most effective and efficient manner consistent with conservation of soil, water, and energy resources. (8) Develop efficient drainage and water management criteria for irrigated and potentially irrigable soils of the region.

b. Land Resource Regions and Areas (Austin, 1972):

The Northern Great Plains Research Laboratory is located at latitude 46° 50'N, longitude 100° 55'W, about two miles upstream from the mouth of the Heart River (west of the Missouri River). It is on a glaciated portion of the Missouri Plateau on the eastern edge of the Rolling Soft Shale Plain Area (54) and in the Northern Great Plains Spring Wheat Region (F), as shown in Figure 1. Elevation for most of the station land is 1,750 feet.

Research programs at the Mandan Laboratorey address problems in the Dark Brown Glaciated Plain (53), Rolling Soft Shale Plain (54), Black Glaciated Plains (55), and the Red River Valley of the North (56), all in the Northern Great Plains Spring Wheat Region, and in the Northern Rolling High Plains (58), Northern Smooth High Plains (59), Pierre Shale Plains and Badlands (60), and the Rolling Pierre Shale Plains (63), all in the Western Great Plains Range and Irrigation Region (C).

These Land Resource Areas contain more than 100 million acres of very productive agricultural lands. Rangeland accounts for nearly half the acreage, and many counties in each state exceed 50% of their land area in range (References 7, 8, and 9).

The Mandan Laboratory programs are field oriented, and often the research is conducted on land leased from owners in the problem area, with laboratory and greenhouse work supporting the field research.

c. Climate (Average):

North Dakota has a continental climate characterized by warm summers and cold winters. The climate of eastern North Dakota has been termed "cool temperate subhumid," and that of western North Dakota as "cool temperate semiarid." Long-term precipitation averages range from 20 inches in parts of eastern North Dakota to 13 inches in parts of western North Dakota. A large portion (70 to 80%) of the total annual precipitation is received as rain during the growing season from April to September. Winter precipitation is generally in the form of snow and seldom exceeds 0.2 of an inch of precipitation per week. Annual precipitation fluctuates widely, with the "average" or "normal" year the exception. Open-pan evaporation exceeds precipitation throughout the state, with a long-term average deficit at Mandan of 29 inches when growing season precipitation is compared to evaporation. Wind is a definite climatic factor in the state, with few calm days and rather frequent days of high wind velocities. Temperatures vary throughout the state, but generally, the coldest temperatures occur in the northeast and the warmest in the southwest. Coldest temperature on record for the state was -60° F at Parshall (2/15/36), with the highest temperature on record the same year, 121° F, at Steele (7/6/36). The average frost-free season ranges from 100 days in the north to 130 days in the south.

Specific long-term (1915-1977) climatic features for the Northern Great Plains Research Laboratory include:

Total precipitation 15.8 inches

Growing season precipitation 11.2 inches

Temperature (°F)		
Annual:		
	Mean	41
	Mean maximum	53
	Mean minimum	30
Growing season (Apr-Aug):		
	Mean	60
	Mean Maximum	72
	Mean minimum	47

Wind velocity (mph):	
Annual mean:	5.1
Growing season (Apr-Aug):	2.6
Evaporation (inches):	
Growing season (Apr-Aug): Total	41.0
Snowfall (inches):	
Annual total:	33.9
Frost-free season:	
Frost-free days	134
Last killing frost	May 11
First killing frost	September 2

d. Ecoregions (Bailey, 1976):

The southwestern half of North Dakota (including Mandan) is in the Great Plains Shortgrass Plains Ecoregion, and the northeastern half of the state is in the Prairie Ecoregion. The western two-thirds of South Dakota is in the Great Plains Shortgrass Plains, and the eastern one-third is in the Prairie Ecoregion. The Great plains Shortgrass Plains also extends into the eastern one-half of Montana.

Research at the Northern Great Plains Research Laboratory relates to these Ecoregions in all three states.

e. Ecosystems (Forest Service, 1972):

The major portion of North Dakota and South Dakota and the eastern half of Montana are in the Plains Grassland Ecosystem. The eastern edge of North and South Dakota is in the Prairie Ecosystem. Isolated small areas of several other ecosystems occur in major drainage ways, badlands areas, and low mountains. These isolated ecosystems are important to local range and ranch management and must be considered in planning grazing systems. Research at the Northern Great Plains Research Laboratory addresses problems related to these minor, as well as to the major, ecosystems.

f. Potential Natural Vegetation (Kuchler, 1964):

Western North and South Dakota and the extreme eastern edge of Montana are in the Wheatgrass-Needlegrass (*Agropyron-Stipa*) PNV type. Dominant species are:

Agropyron smithii	western wheatgrass
Bouteloua gracilis	blue grama
Stipa comata	needleandthread
Stipa viridula	green needlegrass

Other common species include:

Agropyron trachycaulum
Antennaria spp.
Artemisia frigida
Carex spp.
Koeleria cristata
Mertensia spp.
Oryzopsis hymenoides
Pentstemon spp.

Other species found in the Plains Grassland Ecosystem:

Andropogon scoparius
Artemisia dranuncula
Artemisia ludoviciana
Aster ericoides
Echinacea angustifolia
Liatris punctata
Psoralea argophylla
Solidago spp.
Stipa spartea

The eastern one-third of North Dakota and a portion of eastern South Dakota are in the Wheatgrass-Bluestem-Needlegrass (*Agropyron-Andropogon-Stipa*) PNV type.

Agropyron smithii	western wheatgrass
Andropogon gerardi	big bluestem
Stipa spartea	needlegrass

Other common species include:

Agropyron trachycaulum
Andropogon scoparius
Artemisia frigida
Artemisia ludoviciana
Aster ericoides
Bouteloua curtipendula
Bouteloua gracilis
Echinacea angustifolia

Koeleria cristata
Liatris punctata
Psoralea argophylla
Rosa arkansana
Solidago missouriensis
Solidago mollis
Stipa comata
Stipa viridula

g. Objectives:

1. Develop germplasm for new and improved cultivars of grasses for use in range and reclamation plantings. Identify disease and nematodes, develop selection criteria to obtain resistance, ascertain variability among germplasm selections, and provide information on genetics and breeding methodology that will aid development of superior cultivars.

2. Determine germplasm and cultivars of hay and pasture grasses with improved forage and seed yields, nutrition, persistence, disease resistance, and winter hardiness. Determine cytotaxonomic relationships within and among genera, develop techniques for clonal propagation and for making wide crosses.

3. Determine plant physiological processes applicable to selection for improved forage grasses and to investigate plant physiological processes as they relate to grassland management.

4. Produce persistent, productive, and high nitrogen producing legume germplasm suitable for range use in the Northern Great Plains.

5. Improve utilization of native rangelands and seeded pastures through management, fertilization, and animal nutrition to increase beef production per animal and per land unit. Determine best use of introduced grasses with or without native range and relationship between animal performance and forage chemical composition

6. Develop improved seeding, fertilizing, and grazing management practices on rangeland to increase beef production per animal and per land unit.

7. Evaluate techniques for vegetative establishment, plant species adaptability, sustained vegetative production, and vegetative utilization on strip-mined lands to improve the basic understanding and success of disturbed-land rehabilitation.

h. Status:

1. Germplasm collections of Russian wildrye are being screened for seedling vigor and other agronomic characteristics. A technique is being developed to produce autotetraploid Russian wildrye using nitrous oxide.

2. A germplasm collection of western wheatgrass and blue grama from western North and South Dakota has been established and is being evaluated along with other germplasm sources for these species.

3. Germplasm evaluation and development for cyclic selection in crested wheatgrass is in progress.

4. Diseases and nematodes are being identified and evaluated on several grass and legume species.

5. Three selection procedures are being compared to ascertain genetic gain for forage yield and other traits for intermediate wheatgrass.

6. Rate of photosynthesis, activity of ribulose 5-diphosphate carboxylase, specific leaf weight, stomate density, and rate of leaf extension data are being gathered for several species.

7. The effects of water stress on physiological processes are being studied for several grasses. Water-use efficiency and rooting depth are being used to relate water use to phenological data to determine the feasibility of selecting for plants capable of maintaining high turgor potential and rate of photosynthesis during the growing season.

8. The influence of ploidy level on rates of transpiration and photosynthesis has been determined and is being used as selection criteria.

9. A collection of 60 to 70-year old Grimm alfalfa seeds was germinated, and the plants are being used in physiological and genetic studies (part of a joint Fort Collins/Mandan project).

10. A germplasm collection of Medicagos from stands 15 to 70 years old from experiment stations and ranchers in North and South Dakota, Montana, Nebraska, Manitoba, Saskatchewan, and Alberta have been assembled and are being screened for types adapted to range seeding and interseeding (a joint Logan/Mandan project cooperating with Plant Introduction Laboratory, Ames).

11. Two polycross nurseries of birdsfoot trefoil are being

evaluated for persistence and other characteristics for use in rangelands.

12. A strip culture technique developed at Mandan is being used to screen legume germplasm for nitrogen fixing capabilities.

13. The effectiveness of energy and protein supplementation on weight gains of yearling steers grazing native range is being evaluated in an attempt to improve gains during the late summer and fall period.

14. The response to P supplementation by older cows is being compared with that of first-calf heifers calving as 2-year olds.

15. Esophageal fistulated steers are being used to sample vegetation being grazed by steers and cows on various management treatments to establish levels of organic matter digestibility, crude protein levels, and cell wall constituents in the diets throughout the grazing season.

16. Degradation of plant protein by rumen microorganisms is being evaluated on several plant species for several stages of maturity at time of grazing, and as affected by drying and processing techniques using laboratory procedures.

17. The effects of levels of N, P, and K on chemical composition and digestibility of Russian wildrye used for pastures are being studied.

18. Seeded stands of blue grama and sideoats grama are being compared and evaluated for use as summer pasture.

19. Grazing studies are underway comparing fertilized native range with crested wheatgrass and other cool season species for spring grazing as part of a deferment management system. Intensity of grazing, season of use, and complementary pastures are part of the overall long-term grazing research.

20. Effects of livestock on the vegetation and soil of reclaimed mined-land are being studied.

i. <u>Plans</u>:

1. Selection in germplasm source populations of <u>Agropyron desertorum</u>, <u>A. cristatum</u>, <u>A. smithii</u>, and <u>Elymus junceus</u>. Establish new source populations of rangeland forages with help from SCS-PMC and others. Compare cultivars and germplasm to determine establishment ability under stress conditions, yield potential, forage quality, and persistence.

Survey range sites and screen germplasm to determine extent of nematode and pathological problems; ascertain variability for disease resistance and for physiological characteristics associated with forage improvement. Review the literature and conduct genetic and cytogenetic studies to determine the most efficient breeding procedures to maximize genetic gain and to further define problems limiting forage improvement.

2. Select in germplasm source populations of Agropyron intermedium, establish new source populations and gene pools of hay and pasture types of this and other potentially useful species. Ascertain inheritance or heritability of traits identified as important to forage improvement and ascertain genetic gain using modifications of mass selection progeny tests and clonal performance tests. Review literature and observe plant material to become familiar with species phylogeny. Cross closely related species and observe chromosome pairing and breeding behavior of the progeny. Use tissue culture for clonal propagation of specific genotypes and cell culture to facilitate wide crosses

3. Investigate physiological processes as criteria for selecting plants for increased forage grass production. Special emphasis will be in the area of carbon dioxide fixation and plant water relationships as related to dry matter yield. Investigate the physiology of temperature and drought tolerance to forage grass production. Investigate requirements to initiate flowering in forage grasses. Study factors affecting seedling vigor in grasses.

4. Accumulate wide gene base legume germplasm containing a high proportion of presumably drought-tolerant legume plants. Recombine according to ecological or physiological criteria and test under range conditions for adaptability. Species to be tested under range conditions, but not necessarily to be carried on into the breeding program, include M. sativa x falcata hybrids and their parental species; Lotus corniculatus; Cornilla varia; Astragalus cicer; A. crassicarpus; A. falcatus; A. galegiformis; A. striatus; A. strelliatus; A. canadensis; Amorpha canescens; Desmanthus illinoinsis. Studies will be undertaken to determine N-producing ability of the legumes and to determine salient growth and environmental factors contributing towards desirable genotypes and species.

5. Use yearling steers to evaluate a cool-season, warmseason, fall-grazing rotation system. Graze native pastures previously fertilized to determine how long residual fertilizer effects are present after terminating fertilizer treatments and what changes occur in species composition. Use replicated small plots of various treatments and relate forage

production and composition to practical grazing management problems. Evaluate effect of different sources and levels of protein and energy supplementation on weight gains of yearling steers grazing native pasture. Determine effect of phosphorus supplementation on performance of cows and calves grazing native pasture. Use esophageal fistulated steers to sample native pasture for chemical analysis to facilitate optimizing forage-animal production levels.

6. Use field, laboratory, greenhouse, and growth room studies to measure effects of improved management practices on the nutritional aspects of the soil-plant-animal relationship. Simulate different grazing management schemes by clipping Russian wildrye plots at different frequencies. Determine the effect of 36 combinations of N-P-K fertilizer on production and quality of Russian wildrye. Determine the contribution that native and indigenous legumes provide to the range through study of space-planted legumes. Study the contribution of N-fixation by legumes to rangeland grasses. Evaluate cool-season species for adaptability to produce forage in different areas of North Dakota.

7. Conduct greenhouse and field studies to evaluate vegetative responses in terms of basal area, plant density, dry matter production, and chemical composition with regard to such environmental factors as salinity, grazing intensity, soil amendments, soil textures, thickness of respread surface soil, limited availabale soil water, and irrigation with brackish waters. Test plant establishment techniques and species adaptability for disturbed lands, monitor successional trends and stability for pasture and range species and communities with and without grazing; measure animal gains, evaluate measurement techniques for determining pasturage consumption by animals.

j. Opportunities and Needs:

The current forage and range research team has the expertise to look at all the major facets of the high priority researchable problems (Appendix E_2) except modeling. Soils and agricultural engineering expertise assigned to other projects at Mandan can, and do, become involved when needed. The transfer of Dr. James F. Power left a void in the soil fertility areas, particularly as it relates to the N-cycle under grasslands. A high priority need for all projects at Mandan is reinstatement and funding of this position.

The major research needs were evaluated in relation to the Research Planning Conference held at Mandan, October 17-19, 1978. Programs have been directed toward the higher priority research needs, and annual planning conferences held by other agencies have been attended by the Research Leader or his representative to stay in tune with researchable needs of other agencies and of ranchers and

farmers.

The plant physiology needs can be only partly covered by the one physiologist now on the staff. The legume breeding program cannot blossom as it should due to lack of plant physiology input.

A high priority research need in the northern Great Plains at this time is leafy spurge control. Present control techniques are extremely costly, do not work well on grasslands or in wooded areas, and, potentially, are not effective over a long period of time. Assignment of a weed specialist and addition of another plant physiologist, preferably with some herbicide and weed physiology training or experience, to the present staff at Mandan would allow expansion of the range management work into the leafy spurge area.

The greatest present need for the range and range-related project at Mandan is for shoring up monies. Without additional funds, many of the projects listed in Section i cannot be undertaken. Inflation has taken its toll in the past few years. FY80 total support per scientist is $79,000 for NRP 20110 and $77,000 for NRP 20100. After salaries and location support has been removed, the dollars left for each scientist for operating his project is $6,300 for NRP 20110 and $5,800 for NRP 20100. These last figures must cover technicians hired on cooperative agreement and all seasonal help and equipment, supplies, and services, including repair and modification of equipment.

2. Northern Plains Soil and Water Research Center, Sidney, MT:

   a. Mission:

The Northern Plains Soil and Water Research Center is a series of facilities and programs committed to the solution of problems associated with the land and water resources of the Montana Plains area plus portions of North Dakota, South Dakota, and Wyoming. Research objectives are to: (1) Determine the nutrient requirements of cultivated, native, and introduced plant species to optimize plant yield, plant quality, and the utilization of soil and water resources. (2) Quantify microclimate and soil factors that affect evapotranspiration and plant growth and design management systems which beneficially alter the plant environment on cultivated drylands and rangelands. (3) Develop methods of controlling wind and water erosion on range and cultivated lands that are physically and economically compatible with ranch and farm operations. (4) Determine the fate of fertilizer and other soil additives insofar as these materials may become an environmental pollutant. (5) Develop dryland cropping strategies and cultivation systems, including no-till, to maximize production by reducing the proportion of summer fallow, improving weed control, and using water more efficiently. (6) Describe the physical and chemical site characteristics and processes causing salinization of agricultural lands; develop methods of

detecting potential salinity problems; develop remedial practices to halt salinization and reclaim affected lands. (7) Determine site characteristics and effects of soil surface modification on water retention, infiltration, runoff, and sedimentation on rangelands. (8) Develop systems of collecting and storing surface water for livestock and domestic use where ground water sources are not economically available. (9) Develop intensive range management practices such as fertilization and renovation, which are applicable to grazing systems which will optimize use of the range resource.

b. Land Resource Regions and Areas (Austin, 1972):

The Northern Plains Soil and Water Research Center is located at latitude 47° 42'N and longitude 104° 10'W near the confluence of the Yellowstone and Missouri Rivers. It is on the southern edge of the glaciated plain and serves both glaciated and sedimentary plains resource areas. Elevation at the Research Center is 1,940 feet, and the elevation of the surrounding rangeland is about 2,200 feet.

The land resource areas served include the Northern Rolling High Plains (58), Northern Smooth High Plains (59), Brown Glaciated Plain (52), and the western portion of the Dark Brown Glaciated Plain (53). Within this geographic area, there are approximately 37-million acres of range land, 11-million acres of dry cropland, and 650-thousand acres of irrigated cropland (References 7, 8, and 9).

c. Climate (Average):

The resource area served by this location has a continental, semi-arid, temperate climate characterized by warm summers and cold winters. Long-term annual precipitation averages between 12 and 14 inches in most of the resource area. Some range research is being conducted in an area with 10 to 12 inches of annual precipitation. Most of the precipitation occurs as rain in the late spring and early summer with 58% of the annual precipitation occurring between April and July and 79% occurring between April and September. Average growing season varies from 120 to 140 days. Wind is common with relatively few calm days.

Specific long-term (1949-1978) climatic features for this location are:

Total annual precipitation 13.8 inches

Growing season (April-August) precipitation 9.69 inches.

Temperature (°F)[1/]

Annual:	Mean	42
	Mean maximum	55
	Mean minimum	29

Growing season: Mean 60
Mean maximum 74
Mean minimum 46

Wind velocity (mph):[2]

Annual mean: 8.1:
Growing season: 8.5

Evaporation (inches):[2]

Growing season: 37.2

Frost-free season:

Frost-free days: 124
Last killing frost May 17[3]
First killing frost September 18[3]

d. Ecoregions (Bailey, 1976):

Most of the resource area served by this location is in the Great Plains Shortgrass Plains Ecoregion.

e. Ecosystems (Forest Service, 1972):

The eastern half of Montana and the major portion of North Dakota and South Dakota are in the Plains Grassland Ecosystem. The eastern edge of North and South Dakota is in the Prairie Ecosystem. Isolated small areas of several other ecosystems occur in major drainage ways, badlands areas, and low mountains. These isolated ecosystems are important to local range and ranch management, and must be considered in planning grazing systems.

f. Potential Natural Vegetation (Kuchler, 1964):

Western North and South Dakota and the extreme eastern edge of Montana are in the Wheatgrass-needlegrass (*Agropyron-Stipa*) PNV type. Dominant species are:

Agropyron smithii	western wheatgrass
Bouteloua gracilis	blue grama
Stipa comata	needle-and-thread
Stipa viridula	green needlegrass

[1] All temperature values, except annual mean, are for the 1967-1978 period.

[2] Wind velocity and evaporation data are from Williston, North Dakota, about 50 miles from this location. Wind was measured at about a 45-ft height and data are the 1950-1971 average. Evaporation is from a Class A pan (1967-1978).

[3] Killing frost = 32° F.

Other common species include:

Agropyron trachycaulum
Antennaria spp.
Artemisia frigida
Carex spp.
Koeleria cristata
Mertensia spp.
Oryzopsis hymenoides
Pentstemon spp.

Other species found in the Plains Grassland Ecosystem:

Andropogon scoparius
Artemisia dranuncula
Artemisia ludoviciana
Aster ericoides
Echinacea angustifolia
Liatris punctata
Psoralea argophylla
Solidago spp.
Stipa spartea

g. *Objectives*:

1. Determine the relationships between growth and development of range forage species and their environment and develop basic algorithms for these relationships for use in plant-growth modeling.

2. Apply modeling technology to the problems of range research and resource management with the development and evaluation of models that simulate the plant-environment relationships and predict plant response to changing environments.

3. Develop and evaluate methods of managing limited water supplies to increase soil-water recharge and precipitation use efficiency by use of land surface modifications such as contour furrowing and determine the most productive grass and legume species that can be used in conjunction with the enhanced soil water regimes.

4. Develop and evaluate forage systems utilizing introduced and native species, water management practices, fertilization, and combinations thereof to produce both hay and pasture and to then develop sound cultural practices, including grazing management, to most effectively utilize the forage.

5. Determine the nutrient requirements of introduced and native species in relation to specific sites, site conditions, and other factors affecting nutrient availability

including nutrient cycling.

6. Quantitatively and qualitatively describe the phenology, physiology, morphology, growth, and development of major forage species.

7. Determine effects of various range management practices including water conservation, renovation, fertilization, and livestock manipulation on the plant's physiology, nutritive value, growth, and development.

8. Develop species management and selection in conjunction with chemical curing to extend the quality of the grazing season through late fall and winter months.

9. Control range weeds with herbicides, plant management, and grazing manipulation.

10. Determine ways of implementing research findings in range management systems to improve forage production and conserve soil and water resources. Forage yield plus chemical and biological analysis for nutritive quality of forage will be used as criteria of expected animal performance on a seasonal basis.

11. Quantitatively identify environmental factors--precipitation, climatic, edaphic, topographic, and vegetative--which influence runoff, sediment production, and infiltration.

12. Develop techniques, using rainfall simulation, for rapid hydrologic characterization of range sites so that research results can be extrapolated from one location to another.

13. Apply systems analysis techniques to the results of these studies, both empirical and stochastic, to develop mathematical models of watershed systems.

h. Status:

1. Collection of plant growth environmental data has been greatly reduced, and current emphasis is on the analysis and evaluation of data to quantify plant environment relationships.

2. A water balance, climate, crop production model has been modified and adapted for application to rangeland ecosystems. The model is currently being applied to Bureau of Land Management inventory data to help determine long-term average site production from one or two years of yield measurements.

3. Field projects include evaluation of contour furrowing on

panspot and upland range sites. Soil water status, herbage production, and the establishment and productivity of several species seeded into the furrows are being determined.

4. Herbage yield and quality data are being gathered from several sites for various cultural treatments and species.

5. A regression model has been developed to predict yield response as a function of precipitation characteristics, N-rate, and site characteristics.

6. Seasonal growth characteristics, including phenology, morphology, yield, in vitro digestibility, and nutrient content, are being determined for several native and introduced species under different management regimes.

7. A field experiment has been initiated to evaluate chemical curing in terms of its effect on forage quality.

8. An animal model has been developed to predict animal response as a function of forage characteristics such as digestibility and animal characteristics such as kind, class, and size.

9. Runoff, sediment yield, and associated vegetation characteristics are being determined on several small rangeland watersheds.

10. A large-scale rainfall simulator has been constructed and successfully tested.

i. Plans:

Addressing Objectives 1 through 5:

Reduce field experimentation until current data has been analyzed and reported. Major effort will be on model development as a means of synthesizing research results and determining research needs. Much of the future field experimentation will be based on research needs determined from modeling activities. Emphasis will be placed on the application of modeling technology to resource management.

Addressing Objectives 6 through 10:

Evaluation of the effects of season and cultural practices on the growth, morphology, digestibility, and nutrient content will continue. Experiments will be conducted to evaluate chemical curing as a means of preventing the seasonal losses in forage nutritional value. The use of chemicals to abort heading of species such as Russian wildrye, green needlegrass, and foxtail barley as a means of improving forage quality will be studied.

Addressing Objectives 11 through 13:

Following termination of the field phase of the watershed study, major effort will be on the analysis and evaluation of data and reporting of results, including model development. The rainfall simulator will be used on a wide range of range sites to help obtain SCS curve numbers, factors for the Universal Soil Loss Equation (USLE), evaluate grazing systems, and other management practices.

j. Opportunities and Needs:

The range research effort at Sidney is concentrated in two general areas: (1) range forage production, and (2) rangeland hydrology. Seeded pastures, fertilization, and water conservation treatments, such as contour furrowing, are being studied as means of increasing range forage supplies. In terms of climatic growing conditions, Sidney is about midway between Mandan and Miles City and represents a large portion of the glaciated plains. Seeded pastures are well adapted to this area and could play an increasingly important role in the livestock industry of this region. Current research at this location is making significant contributions in quantifying yield limiting parameters and characterizing native and introduced species in terms of seasonal productivity and quality. There is a great need to expand this work to other species and to include studies of adaptability, culture, and management over a wide range of site conditions, and to develop optimum forage systems based on livestock nutritional needs and the seasonal yield and quality of various forages. To fully utilize these research opportunites and needs, one additional range scientist and one additional soil scientist are needed at this location plus the support of a weed scientist and a computer-programmer-mathematician.

The rangeland hydrology program at this location is somewhat unique in that it is the only rangeland hydrology research in the Great Plains region where snow is an important source of water for plant growth, stock ponds, and runoff and erosion. There is a need and opportunity to expand this hydrology work in terms of both rangeland and cropland, especially in view of projected PL 208 requirements. An additional hydrologist stationed at this location could make a significant contribution to much needed hydrologic research on both rangeland and cropland.

3. Livestock and Range Research Station (LARRS), Miles City, MT

a. Mission:

The mission of LARRS is to increase range beef production per unit of land area and per unit of economic input. The research effort to accomplish this goal is concentrated in four areas: (1) Improve reproductive efficiency through the study of hormone mechanisms controlling puberty, ovulation, multiple ovulation, and postpartum

estrus; factors affecting calving difficulty and means of reducing losses at calving; and development of procedures for nonsurgical embryo transfer. (2) Improvement of cattle through breeding and selection, including line breeding, crossbreeding, and development of new types of cattle to meet predetermined characteristics. (3) Improve the performance and productivity of cattle through better nutrition. (4) Improve the productive capacity of the range through improved management, control of undesirable plants, and use of improved native and introduced forage species.

b. Land Resource Regions and Areas (Austin, 1972):

The Land Resource Region served by LARRS is the Western Great Plains Range and Irrigation Region (G), with much of the research also applicable to the more arid portions of the Northern Great Plains Spring Wheat Region (F). Much of the animal research information has national and international application.

LARRS is located on the eastern sedimentary plains of eastern Montana near the point where the Tongue River joins the Yellowstone River. The latter flows through the station, and the Tongue River forms most of the eastern boundary of the station. The range research involving vegetation studies is applicable to most of the semiarid areas of the Northern Great Plains receiving 10-14 inches of annual precipitation. Studies involving plant-animal relationships often have application to a much wider geographical area than that delineated by annual precipitation. Many of the counties in eastern Montana, where this research is particularly applicable, consist of 80-90% or more rangeland.

LARRS has approximately 53,000 acres of rangeland and 2,000 acres of irrigated cropland that are typical of much of the area it serves. Over 95% of the research conducted by the LARRS research staff is done on station land and with station-owned livestock.

c. Climate (Average):

Eastern Montana has a climate typical of the semiarid Great Plains region marked by abundant sunshine, low relative humidity, moderate winds, low precipitation, and wide daily and seasonal variations of temperature. Annual precipitation varies considerably from year to year and throughout the growing season. The average annual precipitation at Miles City is 13.8 inches, but annual precipitation as low as 6.06 inches and as high as 22.75 inches have been recorded. Most of the total precipitation is received as rainfall between April 1 and September 1, being heaviest in May and June. The average frost-free period is 135 days, with the average date of the last killing frost being May 1 and the first killing frost being October 2. The summer and winter extremes vary greatly. The highest temperature recorded is 112° F and the lowest -65° F. These are extreme temperatures that are seldom reached and are of short duration. The annual mean temperature is 44° F. The elevation is

2,350 feet. Evapotranspiration potentials exceed precipitation at the lower elevations, being 29 inches at Miles City.

d. Ecoregions (Bailey, 1978):

LARS is located within the Great Plains Shortgrass Plains which covers much of the eastern half of Montana. The research conducted at LARRS applies primarily to this ecoregion.

e. Ecosystem: (Forest Service, 1972):

Eastern Montana falls primarily in the Plains Grassland Ecosystem. Isolated areas of other ecosystems occur in major drainage ways, badlands, and mountainous areas. LARRS range research addresses problems in each of these ecosystems except for those in mountainous areas.

f. Potential Natural Vegetation (Kuchler, 1964):

Eastern Montana is located in the glaciated plains (northern part) and the sedimentary plains (southern part). In each of these areas, vegetation is characteristic of the soils on which they grow. Between the two major areas, there is considerable overlap of major plant species, so they will be listed together.

The eastern edge of Montana is in the Wheatgrass-Needlegrass (*Agropyron-Stipa*) PNV type, and the major portion of the remainder of the Brown Glaciated Plain, Northern Rolling High Plains, and Northern Smooth High Plains of Montana is in the Grama-Needlegrass-Wheatgrass (*Bouteloua-Stipa-Agropyron*) PNV type.

Dominant species of both PNV types indlude:

Agropyron smithii	western wheatgrass
Bouteloua gracilis	blue grama
Stipa comata	needleandthread

The Wheatgrass-Needlegrass PNV type also includes:

Stipa viridula	green needlegrass

Other common species include:

Grama-Needlegrass-Wheatgrass type:

Agropyron spicatum
Andropogon scoparius
Artemisia frigida
Carex filifolia
Chrysopsis villosa
Gutierrezia sarothrae

Koeleria cristata
Liatris punctata
Muhlenbergia cuspidata
Poa secunda
Sporobolus cryptandrus
Stipa viridula

Wheatgrass-Needlegrass type:

Agropyron trachycaulum
Antennaria spp.
Artemisia frigida
Carex spp.
Koeleria cristata
Mertensia spp.
Oryzopsis hymenoides
Pentstemon spp.
Andropogon scoparius
Aremisia dranuncula
A. ludoviciana
Aster ericoides
Echinacea angustifolia
Liatris punctata
Psoralea argophylla
Solidago spp.
Stipa spartea

g. Objectives:

1. Improve reproductive performance of grazing beef cows as related to nutrition and to pasture and animal production variables.

2. Develop technology for stimulating increased forage efficiency in the Northern Great Plains.

3. Improve reproductive efficiency in range beef cattle.

4. Maintain and improve a closed line of Hereford cattle, and evaluate the merits of several systems of crossing inbred lines.

5. Improve growth, development, and maternal performance of different biological types of beef cattle.

6. Define nutrient requirements of range cattle, and develop technology required to meet these requirements.

7. Study and evaluate interdisciplinary relationships among potential selection criteria in cattle.

h. Status:

1. Several improved and introduced plant species are being evaluated for grazing use and for vegetating problem soils. These species include bluebunch wheatgrass-quackgrass hybrids, pubescent wheatgrass, sherman big bluegrass, altai wildrye, Russian wildrye, tall wheatgrass, intermediate wheatgrass, alta fescue, and sainfoin.

2. The effects of seeding data and various types of fertilizer are being evaluated in relation to stand establishment, seedling vigor, and date of grazing readiness.

3. Burning and/or chemical treatment for controlling noxious range plants are being evaluated.

4. The effects of moisture regime on carbohydrate reserves in plants are being studied.

5. The use of alfalfa interseeded in contour furrows is being evaluated under grazing conditions.

6. Management techniques required for integrating improved pasture with native range are being evaluated.

7. The effects of range fertilization on animal performance, forage production, and range condition are being evaluated under grazing conditions.

8. Grazing behavior of animals is being studied in relation to range vegetation factors and management practices.

9. Nutritive value of range plants is being studied in relation to other plant and animal variables.

i. Plans:

1. Continue to completion present studies which relate to meeting the mission of the location.

2. As soon as resources permit, increase the emphasis on physiological mechanisms affecting plant development in relation to livestock production, and expand work leading to an improved understanding of factors limiting animal production.

j. Opportunities and Needs:

Understanding all plant-animal relations is critical and a high priority area of research if progress is to be made toward increasing range productivity. The current SEA-AR research effort in this area is minimal and should be expanded. LARRS is one of the best

locations in the United States for doing this type of research. Current assets of the location include 53,000 acres of rangeland, 2,000 acres of irrigated cropland, and a basic cattle herd capable of expansion for additional research.

Current research programs at LARRS address 9 of the 12 research categories used in this report. To facilitate ongoing research, and to allow for redirection and expansion of current programs, the greenhouse facilities at LARRS need to be expanded to permit increased effort in soil-plant-water relationships to support ongoing grazing and field research. Two additional fulltime technicians are needed to adequately carry on current range research efforts. Increasing the range nutrition research staff by 1 SY with adequate funding and technical support would allow expansion of the plant-animal relationship research at this location. Basic research in the plant-animal relationship area would compliment the range research programs in all of the western states. It would be particularly beneficial to the interpretation of long-term plant and grazing data from Miles City and Mandan, and it would enhance the current programs at Sidney, Miles City, and Mandan.

4. Rangeland Insect Laboratory, Bozeman, MT

a. Mission:

The mission of the Rangeland Insect Laboratory is: (1) To describe and develop new pathogens for control of insects on rangeland. (2) To enhance natural regulation of grasshopper populations through manipulation of native or exotic parasites or predators. (3) To develop safe, effective, and environmentally acceptable chemical insecticides, particularly ones adaptable to regulatory programs by USDA-APHIS for control of grasshoppers and mormon crickets. (4) To study basic biology and ecology of rangeland insects as necessary to progress in other goals.

b. Land Resource Regions and Areas Served (Austin, 1972):

Research at the Rangeland Insect Laboratory is applicable to most of the Land Resource Regions and major Land Resource Areas, and to many of the western range ecosystems. In the past 5 years, research at the laboratory has addressed problems in 10 of the western states including a variety of ecotypes within grassland and cold desert formations as well as foothill zones that were transitional to montane forests. Within its resources, the laboratory will investigate any insect problem that threatens efficient utilization of range forage anywhere in the western range ecosystem. However, highest priority problems have been traditionally concerned with grasshoppers and mormon crickets.

Due to the wide application of the research program of the Rangeland Insect Laboratory, Sections c, d, e, and f of this report are not applicable and have been omitted.

g. Objectives:

1. Determine the basic biology and ecology of rangeland insects as necessary to develop control or management techniques.

2. Develop techniques to reduce losses in grasses and legumes by suppressing grasshopper populations.

3. Develop a formula for predicting forage losses caused by insects, particularly grasshoppers.

h. Status:

Current research on Great Plains grasshoppers includes basic biology of the species and development of control methods, including biological types. Particular problems and goals include: (a) A means of preventing forage losses due to feeding by grasshoppers. (b) Develop formulae for predicting forage production, grasshopper densities, and potential forage losses, and thereby determine economic thresholds of grasshopper populations. (c) Assess the feasibility of remote sensing to predict or measure forage production for item b, above.

i. Plans:

Current plans are to continue the effort to develop *Nosema locustae*, to evaluate remote sensing for determination of populations of mormon crickets, to define economic threshold of grasshopper infestations, to develop methods for predicting forage production, and to develop equipment for efficient handling and application of selective bait with large aircraft.

j. Opportunities and Needs:

Progress is being made in areas of chemical control, biological control with pathogens, and determining economic thresholds for insect control. The decision to control insects should be based on expected forage losses in relation to production. From this standpoint, there is need for further study of the ecology, biology, and control of grasshoppers, mormon crickets, and other range insects.

Current SEA-AR staff at the Rangeland Insect Laboratory lacks the expertise required to take advantage of modeling techniques that are currently available. Funding to provide part-time assistance in modeling for a 4-year period is needed, particularly for the grasshopper program. The SEA-AR group also lacks engineering expertise needed for equipment development. Funding is needed to acquire engineering assistance through contract.

Opportunities for cooperative effort with SEA-AR scientists at other locations in the Northern Great Plains are increasing. In

particular, the geneticists at Mandan need assistance in screening germplasm collections of legumes and grasses for evidence of genetic resistance or tolerance to injury by grasshoppers and other insects. The collections of plant materials assembled by the geneticists provide the diversity of plant materials required for such screening. If these cooperative efforts are to be explored, additional funds and technician support will be required.

Opportunities for cooperative effort between the SEA-AR scientists, the State Agricultural Experiment Stations, and with other Federal agencies are also increasing. Resources necessary for SEA-AR scientists to become involved in these cooperative arrangements need to be assessed on an individual basis and SEA-AR support provided when necessary.

V. Research Gaps

At the present time, there is no research effort on rangeland weed control in the Northern Great Plains. There are no serious brush control problems in the area, but leafy spurge and annual bromes are a serious problem and need to be worked on.

There has been very little research on surface hydrology in the Northern Great Plains. The soil is generally frozen during part of, or all of, the snowmelt period. This results in a high proportion of runoff. The benefit from an inch or two of snowmelt water to the soil water supply available for plant growth would have a tremendous impact on forage production. Data will be needed to satisfy the requirements of Section 208 and other legislation.

Evaluation of "best technology" to develop improved grazing systems requires large acreages and the input of scientists in many areas of expertise. The Miles City location has the acreage, some of which is typical of a sizeable portion of the more arid parts of the Northern Great Plains. The state of North Dakota has funded purchase of portions of two ranches to provide a 300-cow Rangeland Research Station. It is located on the Missouri Coteau east of the Missouri River, approximately 90 miles southeast of Mandan, in an area typical of much of the semiarid portion of the Northern Great Plains rangelands. SEA-AR scientists at Mandan have participated in early phases of the planning. Preliminary planning includes grazing systems research, with supporting research being carried on by North Dakota State Experiment Station and Sub-station personnel; however, the long history of grazing research by SEA-AR at Mandan is looked upon by State scientists as the background for much of the new work. SEA-AR needs to prepare to participate in the research at the proposed new station and to plan to expand the work at Miles City to complement the new work in North Dakota.

Most of the other high priority rangeland research needs could be addressed by adding to the expertise now in the Northern Great Plains, particularly at Mandan, Miles City, and Sidney. Manpower and funds are limited at all three locations. Additional expertise in plant physiology, soil fertility, weed science, and other related fields is needed, particularly for the breeding

program at Mandan. The entomology staff at Bozeman is already spread too thin, but their expertise is needed in programs at the other three locations.

Closing of the SEA-AR forage and range position at Bozeman a few years ago left a gap in urgently needed research on the complementary use of irrigated forages as part of the rangeland management system common in much of eastern and central Montana. Among items needing research are birdsfoot trefoil seed production for the West (can outyield Midwest seed production 3 to 1 with controlled water application in a dry zone); integration of forage resources to provide a means of using all feed sources to best advantage in an area of irrigation-dryland crop-rangeland livestock production; and basic research on differences between species in ability to absorb P from relatively insoluble sources.

Very little of the current SEA-AR research program in the Northern Great Plains addresses problems unique to the mountain and intermountain portion of Montana and to the Black Hills area of South Dakota. Research in other "sub-regions" may apply to these areas and should be so identified.

VI. References

1. Austin, M. E. 1972. Land Resource Regions and Major Land Resource Areas of the United States. USDA Agr. Handbook No. 296.

2. Baily, Robert G. 1976. Ecoregions of the United States. Forest Service, USDA.

3. Forest Service. 1972. The Nation's Range Resources--A Forest-Range Environmental Study (FRES). USDA Forest Service Report No. 19.

4. Garrison, George A. et al. 1977. Vegetation and Environmental Features of Forest and Range Ecosystems. Forest Service, USDA, Agric. Handbook No. 475.

5. Kuchler, A. W. 1964. Potential Natural Vegetation of the Conterminous United States. American Geographical Society Special Publ. No. 36.

6. Merkel, D. L. et al. 1974. Plant Materials. Report of Range Rehabilitation and Equipment Work Conference, Tucson, Arizona.

7. Montana Department of Natural Resources and Conservation. Revised 1971. Montana Rangeland Resource Program. Peter V. Jackson, Ed. Published by Cooperative Extension Service, MSU, Bozeman, Montana.

8. Society for Range Management and Old West Regional Commission. 1977. North Dakota Rangeland Resources. J. C. Shaver, Coordinator.

9. Society for Range Management and Old West Regional Commission. 1977. South Dakota Rangeland Resources. Rodney Baumberger, Coordinator.

REPORTS IN THIS SERIES

Evans, R. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Great Basin and Northwest. 1980. SEA-AR range research in the Great Basin and Northwest (Idaho, Nevada, Oregon, Utah, and Washington). Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

Herbel, C. H., P. L. Sims, W. A. Laycock, R. J. Lorenz, R. A. Evans, K. G. Renard, SEA-AR Rangeland Scientists in the 17 Western States, R. F Barnes, and G. E. Carlson, National Program Staff Scientists. 1980. Range research, an assessment of current problems and a strategy for the future: A summary of range research by SEA-AR in the 17 western states. Agricultural Research, Science and Education Administration, U. S. Department of Agriculture. 18 pages.

Laycock, W. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Central Great Plains. 1980. SEA-AR range research in the Central Great Plains (Colorado, Kansas, Nebraska, and Wyoming). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Lorenz, R. J., J. R. Wight, R. J. Kartchner, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Northern Great Plains. 1980. SEA-AR range research in the Northern Great Plains (Montana, North Dakota, and South Dakota). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Renard, K. G., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southwest. 1980. SEA-AR range research in the Southwest (Arizona, California, and New Mexico). Agricultural Research, Science and Education Administration, U. S. Deparment of Agriculture.

Sims, P. L., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains. 1980. SEA-AR range research in the Southern Great Plains (Oklahoma and Texas). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

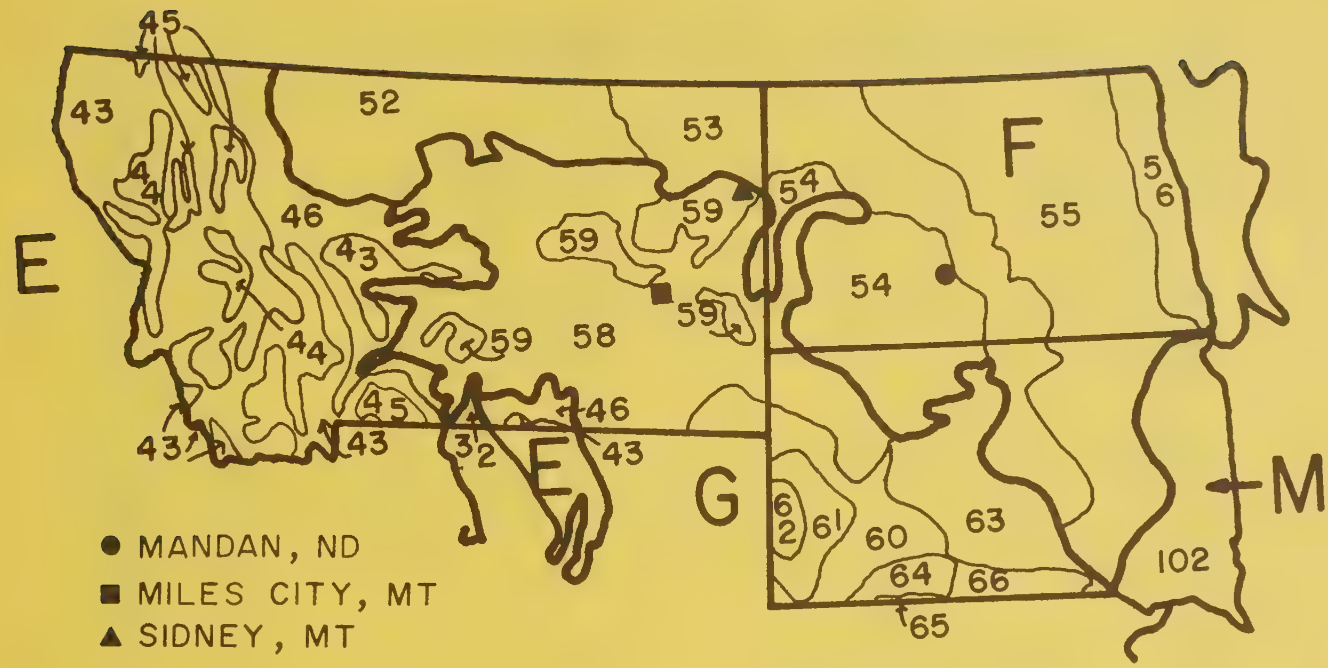


Figure 1. Land resource regions and major land resource areas of North Dakota, South Dakota, and Montana (from Austin, 1972).

Legend

E. - ROCKY MOUNTAIN RANGE AND FOREST REGION

43 - Northern Rocky Mountain
44 - Northern Rocky Mountain Valleys
45 - Alpine Meadows and Rockland
46 - Northern Rocky Mountain Foothills

F. - NORTHERN GREAT PLAINS SPRING WHEAT REGION

52 - Brown Glaciated Plain
53 - Dark Bropwn Glaciated Plain
54 - Rolling Soft Shale Plain
55 - Black Glaciated Plain
56 - Red River Valley of the North

G. - WESTERN GREAT PLAINS RANGE AND IRRIGATION REGION

58 - Northern Rolling High Plains
59 - Northern Smooth High Plains
60 - Pierre Shale Plains and Badlands
61 - Black Hills Foot Slopes
62 - Black Hills
63 - Rolling Pierre Shale Plains
64 - Mixed Sandy and Silty Tableland
66 - Dakota-Nebraska Eroded Tableland

H. - CENTRAL FEED GRAINS AND LIVESTOCK REGION

102 - Loess, Till, and Sandy Prairies

Appendix A. Forest-rangeland types, areas, conditions, stocking rates, and production in the Northern Great Plains States of Montana, North Dakota, and South Dakota.[1/]

Ecosystem	Area				Condition (US)				Grazed (US)	Stocking Rate (US)	Total Stocking[2/]	
	MT	ND	SD	Total	Good	Fair	Poor	Very Poor			Present	Potential
	-------1,000,000 acres-------				--------------%--------------				%	AUM/a	---1,000 AUM's----	
Plains Grasslands	37.0	12.1	21.9	71.0	14.7	34.2	39.6	11.5	98	0.294	20,500	68,300
Prairie	0.0	0.2	1.4	1.6	14.0	34.2	38.1	13.7	95	1.090	1,700	5,800
Mountain Grasslands	11.8	0.0	0.1	11.9	17.5	36.2	31.2	15.1	97	0.319	3,700	12,900
Mountain Meadows	0.2	0.0	0.0	0.2	32.4	38.8	21.1	7.7	79	0.613	100	300
Wet Grasslands	<0.1	0.0	0.0	0.0	17.0	27.6	20.7	34.7	79	0.663	0	0
Sagebrush	4.0	0.0	<0.1	4.0	12.3	36.1	35.0	16.6	89	0.182	600	2,400
Pinyon-juniper	0.5	0.0	<0.1	0.5	9.1	28.6	44.4	17.9	88	0.073	30	130
Chaparral-mountain shrub	0.3	0.0	0.0	0.3	11.8	24.0	37.9	26.3	95	0.125	40	160
Alpine	0.3	0.0	0.0	0.3	42.8	27.1	28.7	1.4	70	0.045	10	20
Hardwoods	0.5	0.0	0.1	0.6	--	--	--	--	56	0.059	20	40
Oak-hickory	0.0	0.1	0.1	0.2	--	--	--	--	28	0.253	10	20
Elm-ash-cottonwood	0.0	0.0	0.2	0.2	--	--	--	--	10	0.213	4	10
Aspen-birch	0.0	0.1	0.0	0.1	--	--	--	--	--	--	--	--
Ponderosa Pine	2.6	0.0	1.3	3.9	--	--	--	--	74	0.059	170	340
Douglas Fir	5.6	0.0	0.0	5.6	--	--	--	--	52	0.049	140	280
Lodgepole Pine	6.4	0.0	0.0	6.4	--	--	--	--	56	0.011	40	80
Fir-spruce	2.6	0.0	<0.1	2.6	--	--	--	--	51	0.028	40	80
Hemlock-sitka spruce	0.2	0.0	0.0	0.2	--	--	--	--	0	0.000	0	0
Larch	1.3	0.0	0.0	1.3	--	--	--	--	41	0.147	80	160
Western White Pine	0.1	0.0	0.0	0.1	--	--	--	--	48	0.234	10	20
TOTAL	73.4	12.5	25.1	111.0							27,194	91,040

[1/]Partially obtained from and based on, "An Assessment of the Forest and Range Land Situation in the United States," (Forest Service FS-345, 1980).

[2/]Present stocking = (total area) x (% grazed) x (stocking rate). Potential stocking was calculated by assuming that good, fair, poor, and very poor range conditions produced 80, 50, 30, and 10%, respectively, of potential. Based on the ecosystems with condition data, we assumed that the potential stocking for the remaining ecosystems could be doubled.

Appendix B. Livestock and animal units in the Northern Great Plains States of Montana, North Dakota, and South Dakota, 1977 (Agricultural Statistics, 1977).

Class of livestock	Number MT	Number ND	Number SD	Number Total	Animal Units[1/] MT	Animal Units[1/] ND	Animal Units[1/] SD	Animal Units[1/] Total
	--------1,000 head--------				-------1,000 units--------			
Beef Cows	1,549	1,060	1,388	3,997	1,549	1,060	1,388	3,997
Replacement heifers	238	139	161	538	167	97	113	377
Bulls	88	51	59	198	110	64	74	248
Calves under 500 lb	762	535	1,135	2,432	305	214	454	973
Total cattle	2,637	1,785	2,743	7,165	2,131	1,435	2,029	5,595
Ewes	410	158	510	1,078	82	32	102	216
Wethers and rams	14	6	15	35	4	2	4	10
Lambs	116	36	100	252	12	4	10	26
Total sheep	540	200	625	1,365	98	38	116	252
Total					2,229	1,473	2,145	5,847

1/ 1 cow = 1.0 AU; 1 heifer = 0.7 AU; 1 bull = 1.25 AU; 1 calf = 0.4 AU; 1 ewe = 0.2 AU; 1 wether or ram = 0.25 AU; 1 lamb = 0.1 AU.

Appendix C. Estimated numbers of big game in the Northern Great Plains States of Montana, North Dakota, and South Dakota (from the American Hunter 6(8):101-104, 1978).

	Number MT	Number ND	Number SD	Number Total	Animal Units[1/] MT	Animal Units[1/] ND	Animal Units[1/] SD	Animal Units[1/] Total
	-------1,000 head-------				------1,000 units-------			
Bighorn sheep	*[2/]	0.2	.0	0.2	--	T	.0	--
Black bear	*	.0	.0	--	--	.0	.0	--
Mule deer	*	20.0	75.0	95.0	--	5.0	18.8	23.8
Whitetail deer	*	80.0	120 0	200.0	--	20.0	30.0	50.0
Elk	*	.0	2.0	2.0	--	.0	1.3	1.3
Pronghorn antelope	*	9.2	33.5	42.7	--	1.6	5.7	7.3
Moose	*	0.1	.0	0.1	--	--	.0	--
Total					--	26.6	55.8	82.4

1/ 1 elk = .67 AU; 1 deer = .25 AU; 1 sheep = .20 AU; 1 pronghorn = .17 AU (Heady, H. F., 1975. Range Management. McGraw-Hill, New York).

2/ *No estimates available.

Appendix D. Species with potential for seeding in the Northern Great Plains States States of Montana, North Dakota, and South Dakota (from Merkel et al., 1974).

Latin name	Common name	Montana	North Dakota	South Dakota
	Cool Season Species			
Pao ampla	Bluegrass, big	X	X	
Poa cambyi	Bluegrass, camby	X	X	X
*Poa pratensis	Bluegrass, Kentucky	X	X	X
Poa secunda	Bluegrass, sandberg	X	X	X
Poa glaucantha	Bluegrass, upland	X		
Bromus biebersteinii	Brome, meadow	X	X	
*Bromus marginatus	Brome, mountain	X		
*Bromus inermis	Brome, smooth	X	X	
Festuca viridula	Fescue, green	X		
Festuca ovina var. duriuscula	Fescue, hard	X	X	X
*Festuca idahoensis	Fescue, Idaho	X		
Festuca rubra	Fescue, red	X		
Festuca ovina	Fescue, sheep	X	X	X
Festuca arundinacea	Fescue, tall	X	X	
*Alopecurus arundinaceus	Foxtail, creeping (meadow)	X	X	X
Alopecurus pratensis	Foxtail, meadow	X		
*Oryzopsis hymenoides	Indian ricegrass	X	X	X
Poa fendleriana	Muttongrass		X	X
Stipa comata	Needleandthread	X	X	X
*Stipa viridula	Needlegrass, green	X	X	X
*Arrhenatherum elatius	Oatgrass, tall	X		
*Dactylis glomerata	Orchardgrass	X	X	X
*Lolium perenne	Ryegrass, perennial	X	X	X
Oryzopsis miliacea	Smilegrass	X	X	
Bromus mollis	Soft-chess	X		
*Phleum pratense	Timothy	X	X	X
Agropyron inerme	Wheatgrass, beardless	X		
Agropyron spicatum	Wheatgrass, bluebunch	X	X	
*Agropyron destorum	Wheatgrass, crested (desert)	X	X	
*Agropyron cristatum	Wheatgrass, crested (fairway)	X	X	
*Agropyron intermedium	Wheatgrass, intermediate	X	X	
*Agropyron trichophorum	Wheatgrass, pubescent	X	X	
*Agropyron sibericum	Wheatgrass, Siberian	X	X	
*Agropyron trachycaulum	Wheatgrass, slender	X	X	
Agropyron riparium	Wheatgrass, streambank	X	X	
*Agropyron elongatium	Wheatgrass, tall	X	X	X
*Agropyron dasystachyum	Wheatgrass, thickspike	X	X	X
*Agropyron smithii	Wheatgrass, western	X	X	X
*Elymus cinereus	Wildrye, basin	X		X
Elymus glaucus	Wildrye, blue	X		X
Elymus canadensis	Wildrye, Canada	X	X	X
Elymus triticoides	Wildrye, creeping (beardless)	X		
*Elymus junceus	Wildrye, Russian	X	X	X
	Warm Season Species			
*Andropoyon gerardu	Bluestem, big	X	X	X
*Andropoyon scoparius	Bluestem, little	X	X	X
Andropoyon hallii	Bluestem, sand	X	X	X
*Buchloe dactyloides	Buffalograss	X	X	X
*Phalaris arundinacea	Canarygrass, reed	X	X	X
Spartina pectinata	Cordgrass, prairie	X	X	X
Sporobolus cryptandrus	Dropseed, sand	X	X	X
*Bouteloua gracilis	Grama, blue	X	X	X
*Bouteloua curtipendula	Grama, sideoats	X	X	X
*Sorghastrum nutans	Indiangrass (yellow)		X	X
Sporobolus airoides	Sacaton, alkali	X		

Appendix D. (Continued)

Latin name	Common name	Montana	North Dakota	South Dakota
	Warm Season Species Continued)			
Calamovilfa longifolia	Sandreed, prairie	X	X	X
*Panicum virgatum	Switchgrass		X	X
*Medicago sativa	Alfalfa	X	X	X
Medicago falcata	Alfalfa, sickle	X		
Sanguisorba minor	Barnet, small	X		
Trifolium fragiferum	Clover, strawberry	X	X	X
*Trifolium repens	Clover, white	X	X	X
Lupinus angustifolius	Lupine, blue	X	X	
Medicago lupulina	Medic, black	X	X	X
Astrigalus cicer	Milkvetch, cicer	X	X	
*Onobrychis viciaefolia	Sainfoin	X	X	
*Melilotus spp.	Sweetclover	X	X	X
Lotus uliginosus	Trefoil, big	X	X	X
*Lotus corniculatus	Trefoil, birdsfoot	X	X	X
Lotus tenuis	Trefoil, narrowleaf	X		X
Vicia enuifolia	Vetch, bramble	X	X	X
*Coronilla varia	Vetch, crown	X	X	X
Vicia pannonica	Vetch, Hungarian	X	X	X
Purshia tridentata	Bitterbrush, antelope	X		
Cercocarpus montanus	Mahogany, mountain	X	X	X
Artemesia tridentata vasevana	Sagewart	X	X	X
Atriplex canescens	Saltbrush, fourwing	X		
Chrysothamnus nauseosus	Rabbitbrush, rubber	X		
*Eurotia lanata	Winterfat	X	X	X

NOTE: Many of these species are extremely limited in use for seeding due to lack of seed and/or problems in seedling establishment. Those preceded by asterisk (*) are most commonly used.

Appendix E[1]. Information available and research needed in the Northern Great Plains States of Montana, North Dakota, and South Dakota (based on a survey of SEA-AR scientists).

	Research information available 1/	Research Needs 2/
I. Inventory and Classification		
A. Census of:		
1. Vegetation	2.5	2.6
2. Forage utilization	2.2	3.1
3. Soil stability	2.3	3.1
4. Animal population	2.2	2.4
5. Animal movements	2.0	2.4
6. Weather	2.4	2.5
B. Determination of Range Trends	2.3	3.7
C. Site Potential	2.1	3.8
D. Assessment of Annual Forage Crops	2.1	3.3
E. Land Use	2.3	3.1
II. Improved Plants		
A. Germplasm		
1. Collection	2.1	4.2
2. Preservation	2.2	3.5
3. Species relationships	2.0	4.3
B. Evaluate Adaptability	2.1	4.1
C. Breeding		
1. Stress	1.9	4.8
2. Photosynthetic efficiency	1.7	3.7
3. Quality and quantity	1.9	4.2
4. N-fixation	1.7	4.6
5. Disease and insect resistance	1.9	3.9
6. Water use efficiency	1.8	4.7
D. Seed Production	2.1	4.2
III. Revegetation		
A. Availability of Plant Materials	2.2	4.2
B. Germination	2.1	4.0
C. Seedling Establishment	2.1	4.5
D. Methods	2.1	4.1
E. Grazing Adaptability	2.0	3.9
IV. Ecology, Damage, and Control of Pests		
A. Unwanted Plants	2.2	4.0
B. Diseases	2.0	3.7
C. Nematodes	1.8	3.5
D. Insects	2.1	3.5
E. Rodents	2.2	2.6
F. Rabbits	2.3	2.0
V. Other Manipulative Treatments		
A. Fertilization	2.4	3.4
B. Mechanical Treatments (ripping, furrowing, etc.)	1.7	3.7
C. Moisture Conservation	2.0	4.3
D. Development of Animal Water	2.2	3.1
E. Burning	2.0	3.1

Appendix E_1. (Continued)

		Research information available 1/	Research Needs 2/
VI.	Complementary Pastures		
	A. Seasonability	2.1	3.1
	B. Quantity and Quality	2.1	4.5
VII.	Grazing Systems		
	A. Proper Utilization	2.1	3.1
	B. Stocking Rate	2.2	3.4
	C. Time of Grazing	2.1	4.2
	D. Native Range Alone	2.4	3.2
	E. Native Range and Complementary Pasture	2.1	4.3
	F. Native Range and Mnaipulated Range	2.1	4.2
	G. Manipulated Range	2.2	4.0
VIII.	Effects of Practices III-VII On:		
	A. Water Quality and Quantity	2.2	3.9
	B. Moisture Conservation	2.0	4.2
	C. Erosion and Sedimentation	1.9	3.9
	D. Range Ecology	2.0	3.7
	E. Annual Performance and Behavior	2.1	3.9
IX.	Livestock		
	A. Diet and Nutrition	2.0	4.2
	B. Performance	2.1	4.2
	C. Trampling	2.1	2.6
	D. Behavior	1.9	2.9
	E. Distribution	2.1	2.9
X.	Wildlife		
	A. Population	2.1	2.6
	B. Diet	2.2	3.0
	C. Habit	2.1	2.8
	D. Distribution	2.1	2.6
	E. Wildlife-Livestock Relations	2.0	3.9
XI.	Basic Range Research		
	A. Plant	2.1	4.3
	B. Plant-Environment Interactions	1.9	4.3
	C. Water Use by Plants	2.0	4.3
	D. Plant-Animal Interactions	2.0	4.3
	E. N-fixation	1.9	4.4
XII.	Models		
	A. Analysis		
	1. Prediction	1.6	4.2
	2. Identification	1.7	4.0
	3. Detection of research needs	1.8	4.5
	B. Synthesis or Simulation	1.6	4.0
	C. Management	1.7	4.3

1/ Research Available: Adequate = 3; Inadequate = 2; None = 1.
2/ Research Need: High = 5; High-medium = 4; Medium = 3; Medium-low = 2
Low = 1.

Appendix E_2. Research needs in priority order as identified by SEA-AR scientists in the Northern Great Plains States of Montana, North Dakota, and South Dakota (based on a survey of SEA-AR scientists).

Score[1/]	Item[2/]	Category[3/]
5.0		None
4.9		None
4.8	II. C. 1.	Breeding - stress
4.7	II. C. 6.	Breeding - water use efficiency
4.6	II. C. 4.	Breeding - N fixation
4.5	III. C.	Revegetation - seedling establishment
	VI. B.	Complementary pastures - quantity and quality
	XII. A. 3.	Models - detection of research needs
4.4	XI. E.	Basic range research - N fixation
4.3	II. A. 3.	Improved plants - specie relationships
	V. C.	Other manipulative treatments - moisture conservation
	VII. E.	Native range plus complementary pastures
	XI. A.	Basic range research - plants
	XI. B.	Basic range research - plant-environment interaction
	XI. C.	Basic range research - water use by plants
	XI. D.	Basic range research - plant-animal interaction
	XII. C.	Models - management
4.2	II. A. 1.	Improved plants - germplasm collection
	II. C. 3.	Improved plants - breeding, quality, and quantity
	II. D.	Improved plants - seed production
	III. A.	Revegetation - availability of plant material
	VII. C.	Grazing systems - time of grazing
	VII. F.	Grazing systems - native range plus manipulated range
	VIII. B.	Effects of practices III and VII - moisture conservation
	IX. A.	Livestock - diet and nutrition
	IX. B.	Livestock - performance
	XII. A. 1.	Models - analysis - prediction
4.1	II. B.	Improved plants - evaluate adaptability
	III. D.	Revegetation - methods
	VII. A.	Grazing systems - proper utilization
4.0	III. B.	Revegetation - germination
	IV. A.	Ecology, damage, and control - unwanted plants
	VII. G.	Grazing systems - manipulated range
	XII. A. 2.	Models - identification
	XII. B.	Models - synthesis or simulation
3.9	II. C. 5.	Improved plants - breeding, disease, and insect resistance
	III. E.	Revegetation - grazing adaptability
	VIII. A.	Effects of practices III and VII - water quality and quantity
	VIII. C.	Effects of practices III and VII - erosion and sedimentation
	X. E.	Wildlife - wildlife-livestock relations
3.8	I. C.	Inventory and classification - site potential
3.7	I. B.	Inventory and classification - range trends
	II. C. 2.	Improved plants - breeding, photosynthesis efficiency
	IV. B.	Ecology, damage, and control - diseases
	V. B.	Other manipulative treatment - mechanical
	VIII. D.	Effects of practices III and VII - range ecology
3.6		None
3.5	II. A. 2.	Improved plants - germplasm preservation
	IV. C.	Ecology, damage, and control - nematodes
	IV. D.	Ecology, damage, and control - insects
3.4	I. D.	Inventory and classification - assess annual forages
	V.A.	Other manipulative treatments - fertilization
	VII. D.	Grazing systems - stocking rate
3.3		None
3.2	VII. D.	Grazing systems - native range alone

Appendix E_2. (Continued)

Score[1/]	Item[2/]	Category[3/]
3.1	I. A. 2.	Inventory and classification - census, forage utilization
	I. A. 3.	Inventory and classification - soil stability
	I. E.	Inventory and classification - land use
	V. D.	Other manipulative treatments - development of animal water
	V. E.	Other manipulative treatments - burning
	VI. A.	Complementary pasture - seasonality
3.0	X. B.	Wildlife - diet
2.9	IX. D.	Livestock - behavior
	IX. E.	Livestock - distribution
2.8	X. C.	Wildlife - habit
2.7		None
2.6	I. A. 1.	Inventory and classification - census, vegetation
	IV. E.	Ecology, damage, and control - rodents
	IX. C.	Livestock trampling
	X. A.	Wildlife - population
	X. D.	Wildlife - distribution
2.5	I. A. 6.	Inventory and classification - weather
2.4	I. A. 4.	Inventory and classification - animal population
	I. A. 5.	Inventory and classification - animal movements
2.0	IV. F.	Ecology, damage, and control - rabbits

[1/]Research Need: High = 5; High-medium = 4; Medium = 3; Medium-low = 2; Low = 1.

[2/]See Appendix E for listing in sequential order by subject.

Appendix F. Distribution of scientific effort for range and range-related research by ecosystems in the Northern Great Plains States of Montana, North Dakota, and South Dakota.

Location and scientist	SY's in each ecosystem[1/] A	B	C	
Bozeman				
Hewitt		1.00		
Onsager		1.00		
Henry		1.00		
Rees		1.00		
Mandan				
Barker	0.20	0.80		
Berdahl	0.20	0.80		
Frank		0.55		
Hofmann		1.00		
Karn		1.00		
Krupinsky		0.20		
Lorenz		1.00		
Ries	0.20	0.80		
Wilton		1.00		
Miles City				
Currie		0.60	0.40	
Kartchner		0.50	0.30	
White	0.25	0.60	0.15	
Sidney				
Neff		1.00		
Siddoway		0.20		
White		1.00		
Wight		1.00		
Ecosystem Total	0.85	16.05	0.85	
Grand total				17.75

[1/] A = Praire grassland; B = Plains grassland; C = Sagebrush.

Appendix G. Distribution of scientific effort for range research in each of 12 categories for the Northern Great Plains States of Montana, North Dakota, and South Dakota.

Location and scientist	SY's in each of several categories[1/]											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
<u>Bozeman</u>												
Hewitt				1.00								
Onsager				1.00								
Henry				1.00								
Rees				1.00								
<u>Mandan</u>												
Barker		0.80									0.20	
Berdahl		0.90	0.10								0.10	
Frank											0.55	
Hofmann			0.60				0.30				0.10	
Karn									1.00			
Krupinsky				0.20								
Lorenz			0.15		0.25	0.25	0.20				0.15	
Ries			0.50					0.30			0.20	
Wilton		0.70	0.05	0.10	0.05	0.10						
<u>Miles City</u>												
Currie		0.20			0.20		0.30	0.30				
Kartchner					0.08	0.16			0.56			
White		0.20	0.25	0.20	0.25						0.10	
<u>Sidney</u>												
Neff					0.20			0.70				0.10
Siddoway					0.12	0.08						
White		0.10			0.15				0.25		0.50	
Wight					0.30	0.10		0.20			0.30	0.10
Category Totals	0.00	2.80	1.65	4.50	1.60	0.69	0.80	1.50	1.81	0.00	2.20	0.20
Grand Total												17.75

[1/] Research Categories:

I	Inventory and classification
II	Improved plants
III	Revegetation
IV	Ecology, damage, and control of pests
V	Other manipulative treatments
VI	Complementary pastures
VII	Grazing systems
VIII	Effects of practices III - VII
IX	Livestock
X	Wildlife
XI	Basic research
XII	Models

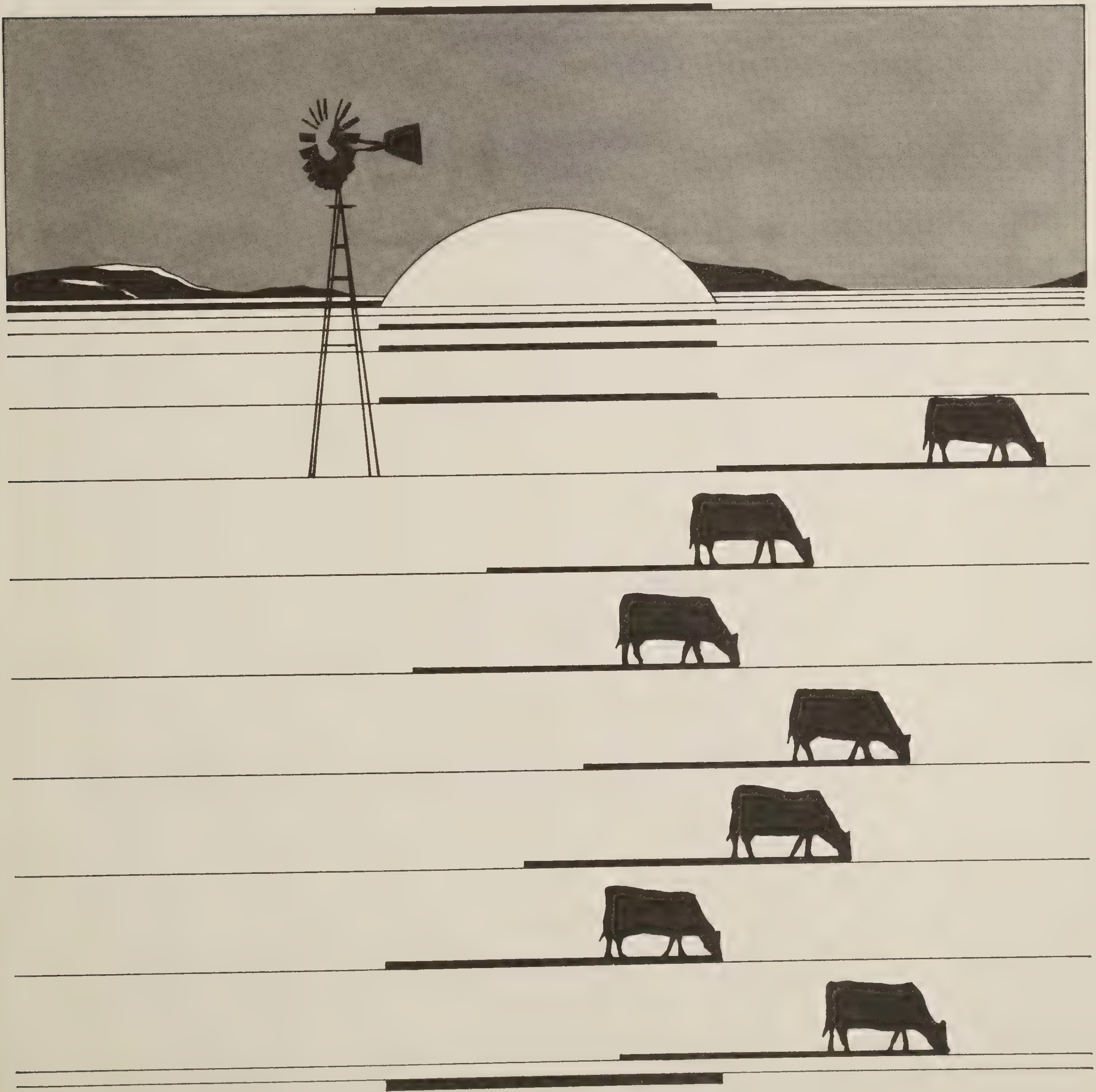
Appendix H. Scientific effort currently assigned to teams, and additional SY's needed to facilitate fulfilling the mission of the team.

Team number	Location/Position title/Scientist	SY's on board	Additional SY's needed
1.	Systematic Range Management		
	A. Mandan		
	Animal Nutritionist (Karn)	1.0	
	Agronomists (Hofmann and Lorenz)	1.3	
	Range Scientist (Ries)	0.1	0.9
	Plant Physiologist		0.5
	Soil Scientist		0.5
	Animal Scientist/Animal Ecologist		1.0
	Economist		0.5
	Modeler		0.5
	B. Miles City		
	Range Scientists (Currie and White)	2.0	
	Animal Nutritionists (Kartchner)	1.0	1.0
	Soil Scientist		1.0
	Animal Ecologist		1.0
	C. Sidney		
	Range Scientists (White and Wight)	0.8	
	Soil Scientist (Siddoway)	0.1	
2.	Revegetation		
	A. Mandan		
	Range Scientist (Ries)	0.9	
	Agronomists (Hofmann and Lorenz)	0.5	
	Soil Scientist		0.5
	Agricultural Engineer/Hydrologist		1.0
	Plant Physiologist		0.5
3.	Brush and Weed Management		
	(No program in Northern Great Plains. Needs effort on leafy spurge as part of on-going program in 1.A. and 2.A., Mandan.)		
	Weed Scientist		1.0
	Weed Physiologist		1.0
4.	Plant Improvement		
	A. Mandan		
	Geneticists *(Barker, Berdahl, and Wilton)	3.0	
	Range Scientist/Agronomist (Lorenz)	0.2	0.3
	Plant Physiologist (Frank)	0.5	0.5
	Plant Pathologist (Krupinsky)	0.2	0.5
	Entomologist (cooperation with 7.A.)		
5.	Water Management		
	A. Sidney		
	Hydrologist (Neff)	1.0	1.0
	Range Scientists (White and Wight)	1.2	
	Soil Scientist (Siddoway)	0.1	1.0
6.	Resource Evaluation Techniques		
	(No program in Northern Great Plains)		
7.	Insects, Diseases, Nematodes, and other Pests		
	A. Bozeman		
	Entomologists (Hewitt, Onsager, Henry, and Ries)	4.0	1.0
	Modeler		1.0
	B. Mandan		
	Plant Pathologist (Krupinsky)	Reported in 4.A.	
8.	Plant-Induced Animal Disorders		
	(No program in Northern Great Plains)		

*Cover cytogenetic and breeding duties.

SEA-AR Range Research Assessment

Central Great Plains



United States Department of Agriculture
Science and Education Administration
Agricultural Research

RANGE RESEARCH

An Assessment of Current Problems

and

A Strategy for the Future

CENTRAL GREAT PLAINS SUBREGION

Kansas, Nebraska, Wyoming, Colorado

Prepared by

W. A. Laycock, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in Colorado, Kansas, Nebraska, and Wyoming.

CONTENTS

SEA-AR Range Research in Colorado, Wyoming, Nebraska, and Kansas

(Central Great Plains)

I. The Situation

The Central Plains, consisting of Colorado, Wyoming, Nebraska, and Kansas is a highly diverse area in climate, topography, vegetation, soils, ecosystems, and land ownership. For convenience of discussion, the region will be further subdivided into three geographic zones from west to east, i.e., The Mountains, The Plains, and The Prairies. The Central Plains may also be subdivided into a number of Land Resource Regions as defined by the Soil Conservation Service (Austin, 1972). A map of the Land Resource Regions and Land Resource Areas in the four states is shown in figure 1.

The largest part of the Central Plains is the Plains zone, which is made up of: the Western Great Plains Range and Irrigated Region (G) in eastern Wyoming, eastern Colorado, and northwestern Nebraska, and the Central Great Plains Winter Wheat and Range Region (H) in southwestern and south-central Nebraska and the western three-fourths of Kansas. Rangelands in these Land Resource Regions often are dominated by short, warm-season grass, mainly blue grama (Bouteloua gracilis). The northern part of the Plains contains more cool-season, mid-grasses than the southern part. Except for the National Grasslands and State School lands, much of the land in the Plains zone is in private ownership.

The eastern edge of the Central Plains (eastern one-fourth of Kansas and Nebraska) is the Prairie zone and is in the more humid Central Feed Grains and Livestock Land Resource Region (M). This area is more similar in climate and land use to the areas further east than it is to the rest of the land in the region to the west. Rangelands in this Land Resource Region are dominated by tall grass species, but native rangelands are not abundant, because most of the land has been converted to crop production. Most of the land is in private ownership.

The western part, or Mountain zone, actually is a highly complex area of many vegetation types. The western part of Colorado and parts of western Wyoming are dominated by the Rocky Mountain Range and Forest Land resource Region (E). The central and southwestern part of Wyoming and a few areas in extreme western Colorado are in the Western Range and Irrigated Land Resource region (D) and are dominated by two different "Desertic Basin" Land Resource Areas which are similar to areas to the west in Utah. The research needs in the Desertic Basins will not be discussed except for the strip mine rehabilitation work. Much of the land in the Mountain zone is in Federal ownership, either Forest Service or Bureau of Land Management.

As indicated above, the region contains a great deal of diversity. The ecosystems, as defined by the FRES study (U.S. Forest Service, 1972), are listed in Appendix A for each state. Appendix A also includes estimates of the percentage of each ecosystem in "Good," "Fair," and "Poor" range condition, the percentage of each ecosystem grazed, the AUMs/Acre, and the present total AUMs. Appendix A includes estimates of present stocking and potential

stocking. Most of these figures are based on the FRES study (U.S. Forest Service, 1972) for the entire ecosystem in the entire western United States. Because these figures are based on the entire ecosystem rather than just the portion of the ecosystem in each particular state, some distorted figures are presented. For example, the percentage of range indicated to be in "Poor" condition in the sagebrush, desert shrub, chaparral, pinyon-juniper, and alpine ecosystems is considered to be much too high for both Wyoming and Colorado. This results in the "Potential Stocking" figure being too high for these ecosystems. More realistic figures are not available for each state at present, however. The U.S. Forest Service is currently assembling figures for the 1980 Assessment of Forest and Range Resources called for by the Resources Planning Act (RPA). It is hoped that these new figures will give us a better base on which to project condition, stocking, etc.

According to 1977 Agricultural Statistics, there are almost 9 million beef cattle and 1.8 million sheep in the four states of the Central Plains Region. Even though the number of animals on feed has been deleted, not all of these animals are on rangelands; but no accurate estimate is available of actual numbers on rangelands. Detailed breakdowns are shown in Appendix B for both cattle and sheep for each state. Appendix C gives the approximate numbers of big game animals in each state.

It is difficult to compare present AUMs of stocking (Appendix A) with animal units of livestock (Appendix B) and big game (Appendix C). Total figures from Appendices B and C indicate 8.2 million AU of livestock and .4 million AU of big game in the Central Plains Region, which could represent over 100 million AUMs of grazing. Of course, all these animals are not on range year-round, but even so, the estimated present stocking of 42 million AUMs (Appendix A) may be too low.

II. Problems and Trends

Because of the diverse vegetation, topography, land ownership, etc., the "Problems and Trends" will be discussed separately for each sub-region.

A. Plains

1. General Problems.

   a. Low inherent productivity of the native rangeland, along with great year-to-year variability in weather, resulting in variable productivity.

   b. Much rangeland is in less than optimum range condition due to past management, and thus, not producing to its potential.

   c. Because of low productivity, the econimic return from many range improvement practices is low, and thus, makes many, if not most, practices uneconomical.

   d. Majority of land is in private ownership, which makes it

difficult to get improved range management practices implemented unless livestock prices are high and more stable.

e. Some herbicides and other pesticides now being used on rangeland may not be available in the near future because of environmental constraints.

f. Lack of ecological and economic knowledge to allow manipulation of vegetation and livestock for optimized production of red meat, fiber, and other products without damaging the resource base.

2. Trends.

a. Short term trends - Land being taken out of use as rangeland and de-emphasis of livestock grazing.

(1) Marginal lands plowed for small grain production.

(2) Lands put under irrigation with center pivot systems.

(3) Lands being used for coal, uranium, trona, and other mineral extraction.

(4) Increased conversion of rangeland into urban and other uses.

(5) Increased emphasis on uses and products other than livestock from rangelands, especially on public land such as National Grasslands.

b. Long term trends - Increased emphasis on importance of rangelands for red meat production.

(1) Reconversion of land to range use as water, energy, or other factors make irrigation, or other cropping, uneconomical.

(2) Croplands now used to produce forage and feed grains for livestock will gradually be switched to produce human food. This will make rangelands more and more important in the total picture of red meat production and will result in increased emphasis on methods of increasing productivity of rangelands.

3. Specific Problems.

a. In areas dominated by warm-season short grass species, there is a lack of:

(1) Enough area seeded to cool-season grasses and legumes to adequately extend the grazing season and supplement native forage supplies.

(2) Improved shrubs and warm-season grasses and legumes for planting on disturbed areas.

(3) Better methods to integrate improved pastures and rangelands to maximize livestock production.

b. Need ability to predict rangeland productivity in advance to allow stocking to reflect forage production.

c. In areas being mined and reclaimed for forage production and grazing, cool-season species should be used to enhance the management scheme.

d. Need to increase efficiency of water use of range and forage plants:

(1) Develop cost-efficient water conservation or harvesting practices.

(2) Identify forage species that are more efficient users of water.

(3) Keep and make use of winter moisture.

e. Lack of knowledge about specific effects of nematodes, diseases, and some insects on forage production and vigor of range plant species.

B. Prairie

1. General Problems.

a. Low inherent productivity, year-to-year weather, and productivity variations of native grasslands (production still higher than plains).

b. Economic pressure to convert native range to croplands.

c. Economic and social pressure to convert forage crops to other crops.

d. Traditional herbicides and pesticides becoming unavailable.

e. Little money available for range improvement work on public lands.

2. Trends.

a. Short Term

(1) Rangeland in public ownership now subject to increasing pressure for uses other than livestock grazing including recreation, wilderness, watershed, wildlife,

and esthetics.

(2) Private lands are being developed at a rapid rate for summer homes, recreation, etc.

b. Long term - Role of rangeland in red meat production will increase because of decreasing supply of other forage and feed sources.

3. Specific Problems.

a. Research has been neglected on revegetation methods and species for reseeding high elevation areas disturbed by mining, roads, and grazing damage.

b. Grazing management systems are being applied which are not based on physiological responses of the plants.

c. Because of predators and economic factors, many mountain areas best adapted to sheep grazing are being grazed by cattle or not at all.

III. Researchable Problems and Goals

A. Research Needs

Each scientist working in the Central Plains on range or related research was asked to evaluate range research needs in 12 categories. The "weighted rating" for each of the categories is given in Appendix E for both the availability of needed information[1] and the need[2] for research. Based on this survey, a prioritized list of research needs for the respective range research categories are:

Priority	Category	Average Rating
1	Basic range research	4.0
1	Improved plants	4.0
2	Revegetation	3.9
2	Grazing systems	3.9
3	Effects of practices	3.8
4	Complementary pastures	3.6
5	Ecology, damage, and control of pests	3.3
5	Inventory	3.3
5	Other manipulative treatments	3.3
6	Models	3.2
6	Livestock	3.2
7	Wildlife	2.6

The lack of spread in the average rating for research needs, and especially for research information available (Appendix E), makes interpretation difficult, and these results should be used very carefully, if at all. As coded, information availability and needs should have been very highly negatively correlated. For the 71 individual items under the 12 major subheadings, the correlation coefficient was -.308. This value was significant, but it should

1/ Research information available: Adequate = 3; inadequate = 2; none = 1.
2/ Research need: high = 5; high-medium = 4; medium = 3; medium-low = 2; low = 1.

have been a much higher value. Some of the reasons for the questionable results are:

1. The sample was quite small. Only 12 scientists responded. Some only checked items in their areas of interest or expertise, while others checked a box for all items. Therefore, the small number responding makes the averages of questionable value. The number responding to each item is shown in Appendix E.

2. This type of questionnaire tends to reflect interest as much as need. A repetitive-type questionnaire, such as used in Delphi-analysis, yields much more accurate results, but also requires a much higher number of respondents.

The following more specific research needs were identified:

1. Forage Improvement and Revegetation

    a. Breed adapted plant species for (1) water use efficiency and resistance to water stress, (2) resistance to insects and disease, (3) improved seedling establishment, and (4) improved seed production.

2. Plant-Animal Relationships and Management Systems

    a. Basic research on physiology and ecology of important native and introduced range species so that grazing systems can be based on plant responses and requirements.

    b. Develop improved grazing systems for native range and integrated native range, improved range, and pastures with emphasis on plant-environment interaction and animal diet, nutrition, and behavior.

3. Management Systems

    a. Identify areas where modeling will enhance existing research efforts and detect research gaps.

    b. Improve methods of determining site potential and the effects of manipulative treatments on range productivity and ecology.

4. Revegetation

    a. Develop improved methods of revegetation including seed mixtures, seed treatment, diversity of species, and use of herbicides.

    b. Rehabilitation and management of disturbed high elevation areas.

5. Water Management

   a. Develop cost-effective methods for improving efficiency of use of limited precipitation.

B. Research Teams

Research teams needed to meet the research needs are listed in Appendix I. Those currently on board are identified by the scientist's name, while those needed are indicated as vacant.

IV. Current Research Effort

Appendices F, G, and H list the scientists currently working on range and range-related research in the Central Plains. Current effort amounts to 12.5 SYs, the division of this effort into the various NRPs, the main ecosystems, and 12 research categories are also shown in Appendices F, G, and H, respectively. Appendix D-1 lists grasses and forbs suitable for planting in the three zones in the Central Plains. Appendix D-2 lists some shrub species that might be suitable for planting in the mountain zone.

A. Research Locations

The following describes the Mission, Objectives, Status of Research, and Research Needs at each research location in the Central Plains.

1. Cheyenne, Wyoming--High Plains Grasslands Research Station

The High Plains Grasslands Research Station, located at Cheyenne, Wyoming, conducts research contributing to three national research programs; 1.0 SY (plus two support scientists) effort on Forage and Livestock Management Systems, and a 3.0 SY effort on Reclamation of Lands Disturbed by Man and Water Conservation. Research activities are cooperative with the University of Wyoming and Colorado State University, and are located on the station and at several mining locations throughout the state.

The Cheyenne Station receives an average of 14.65 inches of precipitation annually. Average temperature is 26° F in January, and 69° F in July. Growing season averages 132 days. Climate at the various work sites (Fig. 1) would be highly variable.

The Forage and Livestock Management research is carried out at the High Plains Grasslands Research Station located in Land Resource Area 67 and at Arlington, located in Land Resource Area 34 (Fig. 1). The station is comprised mainly of rangeland with some dryland seeded pastures and irrigated pasture land, while Arlington includes native sagebrush and juniper range,

and high altitude wet meadows. The mine reclamation research is conducted on rangeland areas in Land Resource Areas 58, 48, and 34. These areas are predominately rangeland with limited cropland. Therefore, the major use of these areas, which embrace about 41 million acres, is livestock grazing.

The ecosystems in Wyoming (U.S. Forest Service, 1972) are listed in Appendix A. The Cheyenne Station is located in the "Plains Grassland Ecosystem" and in the "Great Plains Shortgrass Prairie," but work sites (Fig. 1) occur in many other ecosystems and ecoregions.

The mission of the research headquartered at Cheyenne is:

Develop integrated systems for cow-calf production using native range and complementary improved pastures; develop methods to improve the success and plant diversity of reclaimed lands disturbed by man; improve and manipulate soil-water storage for greater forage production.

Objectives of the research are to:

a. Identify species and cultivars adapted to the High Plains.

b. Evaluate effects of surface modification and row oriented plantings on soil water storage, particularly that derived from snow.

c. Determine cow-calf management on range and improved pasture.

d. Determine structure and function of shortgrass ecosystems and incorporate into models.

e. Study the effects of grazing management systems and environmental factors on animal production and on range and forage plants.

f. Study soil characteristics limiting plant establishment.

g. Determine the minimum and optimum requirements for germination and establishment of native and introduced forbs.

h. Determine the feasibility of planting mixtures of native and introduced grasses on mined lands.

i. Determine the effect of livestock grazing on the vegetation and soil of reclaimed mine lands.

j. Determine the factors that are related to decreased forage quality on reclaimed lands.

Status:

a. First experimental plots and grazing studies established in 1974.

b. Species and management practices for increasing water-use efficiency and forage quality have been identified.

c. Carrying capacity and calf gains were nearly doubled by replacing approximately 10% of native range with crested wheatgrass.

d. Production and utilization of crested and western wheatgrasses were shown, by time-lapse photography, to be greater than indicated by conventional clipping techniques.

e. The diets of cattle grazing native range was determined and found to be different than diets on northern Colorado grasslands.

f. Various subsoil-topsoil ratios were studied to determine their effect on plant growth, and the feasibility of the technique is very good where adequate topsoil is not present.

g. Standing stubble residue was studied and found to be as good as blown and crimped residue for grass establishment on mined lands, cost about 10-25% as much as crimped straw, and was not as susceptible to being blown out by the wind.

h. Three years of tests using 86 species have shown the adaptable species of native and introduced shrubs for use on mined lands.

i. Artemisia vulgaris, an introduced species, has shown good success in reclamation use and has an average protein of 31%, invitro digestibility of 67%, and a volatile oil content of only 0.03%.

j. Production of crested wheatgrass increased significantly due to increased soil moisture and climatological changes when soil ridges and furrows are used to reduce wind velocity and increase infiltration on reclaimed land for snow trapment.

Plans:

Develop stocking rate studies on range-complementary pasture systems. Determine effects of rotation grazing systems (including high intensity-low frequency systems) on beef production and plant communities. Develop models to integrate existing information on range use and livestock production and to identify research gaps. Determine those factors that influence the

germination and establishment of native and introduced woody shrubs and forbs, because direct seeding of shrub and forb species is, both ecologically and economically, the best system for reclaiming disturbed lands. Collect basic data on the effect of grazing on soil compaction, water infiltration, forage production, species diversity, and erosion, and the necessity for special management practices for reclaimed lands. Determine soil chemical and soil-water properties that are limiting factors in revegetation of lands disturbed by man. Determine grazing management systems for reclaimed lands so as not to degrade vegetative and soil resources. Determine the optimum conditions necessary for establishment of woody shrubs and forbs from seed. Develop management systems for high-altitude wet meadows based on phenology and regrowth characteristics of best adapted forage species.

2. Laramie, Wyoming

Laramie is the headquarters for a one-scientist effort in Soil-Water-Air-Sciences research in cooperation with the University of Wyoming Agricultural Experiment Station. The research deals with problems of rangelands and the reclamation of disturbed lands, and jointly-sponsored projects are underway on the University of Wyoming's substations at Archer and Gillette, the U.S. High Plains Grasslands Research Station near Cheyenne, and on coal and uranium mine spoils in Wyoming, and is closely coordinated with the mine reclamation program at Cheyenne.

Laramie receives an average of 11.16 inches of precipitation annually. Average temperature is 20.7° F in January, and 65.2° F in July. Growing season averages 109 days. Climate of work sites would be quite variable.

The research is conducted on rangelands, semi-arid croplands, and disturbed lands of Land Resource Areas 67 (Central High Plains), 58 (Northern Rolling High Plains), and 34 (Central Desertic Basins, Mountains, and Plateaus). Land Resource Areas 67 and 58 cover the eastern one-third of the state embracing about 18 million acres, and Land Resource Area 34 embraces about 23 million acres. The major use of these land resource areas is grazing by livestock. Less than 10% of Resource Area 67 and 58 are in cropland, and even less in Resource Area 34. Ecosystems and ecoregions, where work is being conducted, are discussed in the description for the Cheyenne Station.

The mission of the research is to increase water use efficiency and water conservation on rangelands of the Central Great Plains.

The objectives of the research are to develop an understanding of soil-climate-vegetation relations affecting the conservation and utilization of water and the establishment of vegetative ground cover on mined lands. Determine the fertility manage-

ment practices necessary on reclaimed lands to establish nutrient cycling.

Status:

Research is in progress on nitrogen and phosphrous fertilization on reclaimed lands where topsoil and no topsoil were replaced.

Plans:

Seven sites have been contour-furrowed and seeded. They will be evaluated as to change in forage production. Other research is included in the write-up for the strip-mine research at Cheyenne.

3. Fort Collins, Colorado and the Central Plains Experimental Range

   The Forage and Range Research unit at Fort Collins conducts research mainly on The Central Plains Experimental Range in Land Resource Area 67. Some cooperative strip mine rehabilitation work near Steamboat Springs is being conducted on rangeland in Land Resource Area 48. The research is concentrated in only one NRP (20110) and consists of 5.5 SYs plus one support scientist. Research activities are in cooperation with Colorado State University and a number of other agencies and companies.

   At the Central Plains Experimental Range, average annual precipitation is 12.09 inches. Average temperature is 11° F in January and 54° F in July. Average length of growing season is 128 days.

   The Ecosystems (U.S. Forest Service 1972) for Colorado are listed in Appendix A. The Central Plains Experimental Range is in the "Plains Grassland Ecosystem" and the "Great Plains Shortgrass Prairie Ecoregion" (Bailey, 1976), but work sites are in other subdivisions.

   The mission of the research is to improve vegetation and management practices for the range ecosystems and increase range livestock production efficiency in the Central Great Plains and the Rocky Mountains.

   The specific objectives are:

   a. Develop legume varieties for increased nitrogen fixation, improved forage quality, and increased forage production on semiarid rangelands and improved pastures.

   b. Determine the best adapted species and varieties for saltgrass meadows and other range sites, including those

disturbed by surface strip mining, and develop efficient and economical methods for establishing those plants on disturbed sites on semiarid and lower mountain rangelands.

c. Determine the morphological and physiological traits that relate to cold, heat, and drought resistance of blue grama and other important forage plants during seed germination, seedling emergence, and plant establishment on semiarid rangelands.

d. Select blue grama plants for ability to emerge from deep planting and for high water uptake to increase survival of seedlings in disturbed areas planted to blue grama.

e. Determine the relationship between the death of blue grama and the populations of white grubs and soil-environment factors.

f. Determine plant-soil relations, plant-grazing relations, plant-weather relations, plant-fertilizer relations, and other ecological responses of plants as needed in formulating guidelines for range improvement, grazing management, and the ecological evaluation of potentially valuable new practices.

g. Develop economical feed-supplementation practices and new forage resources for improving livestock nutrition, increasing calving percentage, and increasing beef production on shortgrass rangeland.

Status:

a. Germplasm pools of alfalfa and cicer milkvetch have been released, and a new cultivar of cicer milkvetch is being developed that has better seedling emergence than "Lutana."

b. Good progress is being made in improving saltgrass meadows; evaluating grass-legume mixtures; and establishing shortgrass sod vegetatively, and fourwing saltbush hedges may be efficient for trapping snow.

c. Determined the environmental requirements for development of adventitious roots in blue grama, defined the role of lateral roots in the drought resistance of crested wheatgrass and Russian wildrye, and quantified drought resistance in seedlings of blue grama.

d. Research just initiated.

e. Research just initiated.

f. About three years are needed to complete studies on the

effect of nitrogen fertilization and atrazine on livestock production.

g. Preliminary harvesting equipment for using pricklypear as a supplemental feed are being perfected, singeing equipment is being designed, and techniques for burning in place are being developed. Studies to determine the effect of zinc supplementation on cattle production are nearly complete; the second year of a winter rotation study has been completed, and a preliminary study of cattle diets on sites--with and without fourwing saltbush and *Chenopodium* spp. has just been completed.

Plans:

Identify major range insects and diseases causing production losses. Emphasize techniques for establishing native species. Study ecology and economics of pricklypear control. Study spring and fall deferment of blue grama and develop complementary pastures. Evaluate and develop adapted and more productive legumes. Develop genetic lines of blue grama and determine traits important for seedling growth and establishment.

4. Lincoln, Nebraska

Most of the research at Lincoln, Nebraska is conducted in, and applicable to, the Prairie Regions of the United States. However, the plant breeding and weed control research does have applicability to the Central Plains.

Lincoln is located in the Central Feed Grains and Livestock Land Resource Region (Austin, 1972) (Fig. 1). Forage improvement research at Lincoln has work sites in Land Resource Areas 64, 65, 67, 72, 102, and 106 in Nebraska. Weed control research at Lincoln has work sites in Land Resource Areas 71 and 75 in Nebraska and 106 in both Nebraska and Kansas.

Ecosystems (U.S. Forest Service, 1972) in Nebraska and Kansas are listed in Appendix A. Lincoln is located in the Prairie Parkland Ecoregion (Bailey, 1976), and the remainder of Nebraska and Kansas lies in the Tall-Grass Prairie and Great Plains Shortgrass Ecoregions.

At Lincoln, average annual precipitation is 28.6 inches. Average temperature is 22.2° F in January and 77.3° F in July. The frost-free period averages 186 days.

The mission of the range-related research at Lincoln is grass breeding, genetics, and weed control for the Central Great Plains.

The specific objectives of the research are:

The specific objectives of the research are:

a. Develop basic genetic and cytogenetic information for perennial grasses and develop superior grass germplasm.

b. Develop fundamental knowledge of the biology, ecology, and biochemistry of weeds; develop integrated, safe methods of weed control.

Status:

a. Breeding work is in progress with ten perennial grasses. Field plot operations have been mechanized, and varieties are being developed.

b. Results were recently summarized of long-term studies near Lincoln. Also, reported on control of green sagewort and downy brome in the Sandhills area.

Plans: Development and management of new varieties. Develop biological control of musk thistle and leafy spurge, and continue studies on life cycles of selected weeds.

Needs:

a. Collect, evaluate, and preserve germplasm for use in breeding programs; determine basic genetic information for germplasm collections such as chromosome numbers and the degree of cross fertilization, and breed range plants for improved forage and seed yield, quality, and improved resistance to stress.

2. Develop improved methods of revegetation including seed treatment and the use of herbicides during establishment.

B. Current Research by Research Categories:

The current research being conducted at the four locations in the Central Plains is shown below for the major research categories. The present and needed make-up of the research teams for this research are shown in Appendix I.

1. Forage Improvement

a. Develop legume varieties for increased nitrogen fixation, improved forage quality, and increased forage production on semiarid rangelands and improved pastures (Fort Collins).

b. Identify species and cultivars adapted to the High Plains (Cheyenne).

c. Develop basic genetic and cytogenetic information for perennial grasses and develop superior grass germplasm (Lincoln).

d. Select blue grama plants for ability to emerge from deep planting and for high water uptake to increase survival of seedlings in disturbed areas planted to blue grama (Fort Collins).

2. Revegetation

a. Determine the best adapted species and varieties for saltgrass meadows and other range sites, including those disturbed by surface strip mining, and develop efficient and economical amethods for establishing those plants on disturbed sites on semiarid and lower mountain rangelands (Fort Collins).

b. Determine the morphological and physiological traits that relate to cold, heat, and drought resistance of blue grama and other important forage plants during seed germination, seedling emergence, and plant establishment on semiarid rangelands (Fort Collins).

c. Study soil characteristics limiting plant establishment.

d. Determine the minimum and optimum requirements for germination and establishment of native and introduced forbs (Cheyenne).

e. Determine the feasibility of planting mixtures of native and introduced grasses on mined lands (Cheyenne).

f. Determine the effect of livestock grazing on the vegetation and soil of reclaimed mine lands. Determine the factors that are related to decreased forage quality on reclaimed lands (Cheyenne).

g. Determine the fertility management practices necessary on reclaimed lands to establish nutrient cycling (Laramie).

3. Brush and Weed Management

a. Develop fundamental knowledge of biology, ecology, and biochemistry of weeds, and develop integrated, safe methods of weed control (Lincoln).

4. Water Management

a. Evaluate effects of surface modification and row oriented plantings on soil water storage, particularly that derived from snow (Cheyenne).

5. Plant-Animal Relationships

a. Develop economical feed-supplementation practices and new forage resources for improving livestock nutrition, increa-

sing calving percentage, and increasing beef production on shortgrass rangeland (Fort Collins).

b. Determine cow-calf management on range and improved pasture (Cheyenne).

6. Management Systems

a. Study the effects of grazing management systems and environmental factors on animal production and on range and forage plants (Cheyenne).

b. Determine structure and function of shortgrass ecosystems and incorporate into models (Cheyenne).

c. Determine plant-soil relations, plant-grazing relations, plant-weather relations, plant-fertilizer relations, and other ecological responses of plants, as needed, in formulating guidelines for range improvement, grazing management, and the ecological evaluation of potentially valuable new practices (Fort Collins).

7. Plant-Soil-Water Relations

a. Develop an understanding of soil-climate-vegetation relations affecting the conservation and utilization of water and the establishment of vegetative ground cover on mined lands.

b. Determine the relationship between the death of blue grama and the populations of white grubs and soil-environment factors (Fort Collins).

V. Research Gaps

A. Forage Improvement

1. Sufficient additional disciplines (physiology, agronomy) to support research to develop adapted legumes for arid rangelands.

2. In areas now dominated by warm-season shortgrass species, there is a need for plant breeding research to develop both introduced and native warm-season species to increase productivity and water use efficiency.

3. Need better interface between pathologists and scientists involved in legume and grass breeding.

4. Need additional information on genotype and environmental interaction in grass breeding program. Need to evaluate germplasm at more loactions than currently possible with present personnel.

5. Develop grass varieties that are 15-20% more productive and 10-15% more digestible than the grass varieties that are currently being used in the Central Great Plains. Concurrently acquire genetic information and develop and evaluate breeding methods that would allow the same genetic gains to be made in the following decade.

B. Revegetation

1. Research in revegetation of disturbed high elevation areas.

2. Methods for establishing and improving seed production of native species.

C. Brush and Weed Management

1. Basic information on many of the major weeds is lacking and is needed to achieve more effective weed control practices. Plant species differences and variation within species to weed control practices are areas needing study.

2. Threshold values to determine point degree of weed infestation at which weed control becomes economically feasible. The combinations of factors and values involved are many.

D. Water Management

Research adapting existing or new water conservation practices to shortgrass rangelands.

E. Plant-Animal Relationships

Animal nutrition expertise to bolster research teams.

F. Management Systems

1. Ability to forecast herbage production far enough in advance to set realistic stocking rates.

2. Assemble available data on high mountain meadow research through a modeling effort to identify gaps in knowledge and possible research needs.

3. Expertise in modeling on a permanent basis.

G. Plant-Soil-Water Relations

1. Better interface between entomologists and range scientists to identify existing insect problems and begin research.

2. Need expertise to identify existing or potential disease and nematode problems on rangelands.

H. Missing Geographical Areas

Two extremely productive grassland areas, the Sandhills of Nebraska and the Flint Hills in Kansas, currently have no SEAAR Range Management Research taking place. Unless state research is adequate, these areas are important gaps in our research.

VI. Recommendations

Appendix I lists the research teams thought to be needed to meet the research needs identified in the previous section. The listing of scientists under each team is based upon the recommendations at the November Range Research Planning meeting in Las Cruces and may be revised after discussions have been held with Area Directors, scientists, cooperators, and others. Some specific recommendations for each location are listed below.

A. Strip Mine Rehabilitation (Cheyenne and Laramie)

Some possible additions to the present team are indicated in Appendix I. Closer coordination is needed between the strip mine research being done at Cheyenne and Fort Collins and also with the strip mine hydrology work being done by Woolhiser's group in Fort Collins. Work at Laramie will be phased out as well as personnel and all research headquartered at Cheyenne.

B. Range Management Systems (Cheyenne and Fort Collins)

The range management research at Cheyenne and Fort Collins needs to be closely tied together. Both areas are shortgrass plains sites, but there are important differences. The CPER is predominately blue grama with a low frequency of cool-season species. The site is typical of the Central Plains grasslands in the southern part of the sub-region. The Cheyenne site has many more cool-season species and is more typical of the northern part of the sub-region. Modeling assistance, hired or obtained otherwise with new money at both locations, should help facilitate coordination of the research. Economic input into this research effort is not available and is badly needed.

C. Water Management and Plant-Soil-Water Relations (Fort Collins)

One of the highest priority needs in the Central Plains is more efficient use of the limited precipitation. This includes better methods of harvesting winter snow and trapping or making more efficient use of growing-season precipitation. Greater cooperation will be needed with the soil-water units at Fort Collins, Akron, and Sidney, Montana.

D. Forage Improvement (Fort Collins)

The present effort at Fort Collins consists of a single breeder working on legumes suitable for arid rangelands plus a small

cooperative effort on blue grama. Support of a plant physiologist and an agronomist/range scientist are needed to round out this effort on legumes. Close coordination between the legume breeding efforts at Fort Collins and that being conducted elsewhere should be continued. A staff grass breeder is needed at Fort Collins to work on selection or breeding of a warmseason species to plant on blue grama sites. This work has been started on a small scale with a cooperative agreement with a grass breeder at Colorado State University.

E. Forage Improvement (Lincoln)

The single plant breeder at Lincoln is working alone without adequate support. A technician is needed to assist the grass breeder in evaluating germplasm at additional locations.

F. High Elevation Rangelands (Fort Collins and Cheyenne)

Except for a small effort at Dubois, Idaho, in SEA, and at Logan, Utah, in the Forest Service, research on high elevation rangelands is virtually non-existent in either agency. William McGinnis is currently spending about half time on strip-mine rehabilitation research on lower mountain areas in Colorado. It is recommended that he phase out his effort on shortgrass plains and begin research on revegetation of sub-alpine disturbed areas. A cooperative mountain meadow research program (with University of Wymoming) has been proposed at Cheyenne. It is recommended that no research be started until all of the previous research on mountain meadows has been thoroughly reviewed and analyzed. A systems approach to the assembly of this research data will be possible with the new modeling effort at Cheyenne. This will enable a much more accurate assessment of research gaps on which to base a research program. If further research on use of legumes to meet the nitrogen requirement of mountain meadows is warranted, Dr. Townsend, from Fort Collins, should ba consultant on the research.

G. Weed Management (Lincoln)

This effort appears to be largely confined to the Prairie portion of the region. A close look at the weed research needs of the four-state Central Plains, and of the entire Prairie area of the U.S., should be conducted.

VII. References

Austin, M. E. 1972. Land resource regions and major land resource areas of the United States. U.S. Department of Agriculture Handbook 296, 82+ p.

Bailey, Robert G. 1976. Ecoregions of the United States. U.S. Department of Agriculture, Forest Service. 77 p.

Heady, H. F. 1975. Range Management. McGraw-Hill, New York.

Hull, A. C., D. F. Hervey, Clyde W. Doran, and W. J. McGinnies. 1963. Seeding Colorado range lands. Colo. Agric. Exp. Stn. Bull. 498-S, Colo. State Univ., Fort Collins, 46 p.

Merkel, D. L. et al. 1974. Plant materials. Rep., Range Rehab. and Equip. Work Conf., Tucson, Ariz., 20 p.

Plummer, A. P., D. R. Christensen, and S. B. Monsen. 1968. Restoring big game range in Utah. Utah Div. of Fish and Game Pub. No. 68-3, 183 p.

U.S. Forest Service. 1972. The nation's range resources--a forest-range-environmental study (FRES). USDA Forest Resource Rep. 19, 147 p.

Figure 1 - Legend

B NORTHWESTERN WHEAT AND RANGE REGION
- 13 Eastern Idaho Plateaus

D WESTERN RANGE AND IRRIGATED REGION
- 32 Northern Intermountain Desertic Basins
- 33 Semiarid Rocky Mountains
- 34 Central Desertic Basins, Mountains, and Plateaus
- 37 San Juan River Valley Mesas and Plateaus
- 39 Arizona and New Mexico Mountains

E ROCKY MOUNTAIN RANGE AND FOREST REGION
- 43 Northern Rocky Mountains
- 45 Alpine Meadows and Rockland
- 46 Northern Rocky Mountain Foothills
- 47 Wasatch and Uinta Mountains
- 48 Southern Rocky Mountains
- 49 Southern Rocky Mountain Foothills
- 50 San Luis Valley
- 51 High Intermountain Valleys

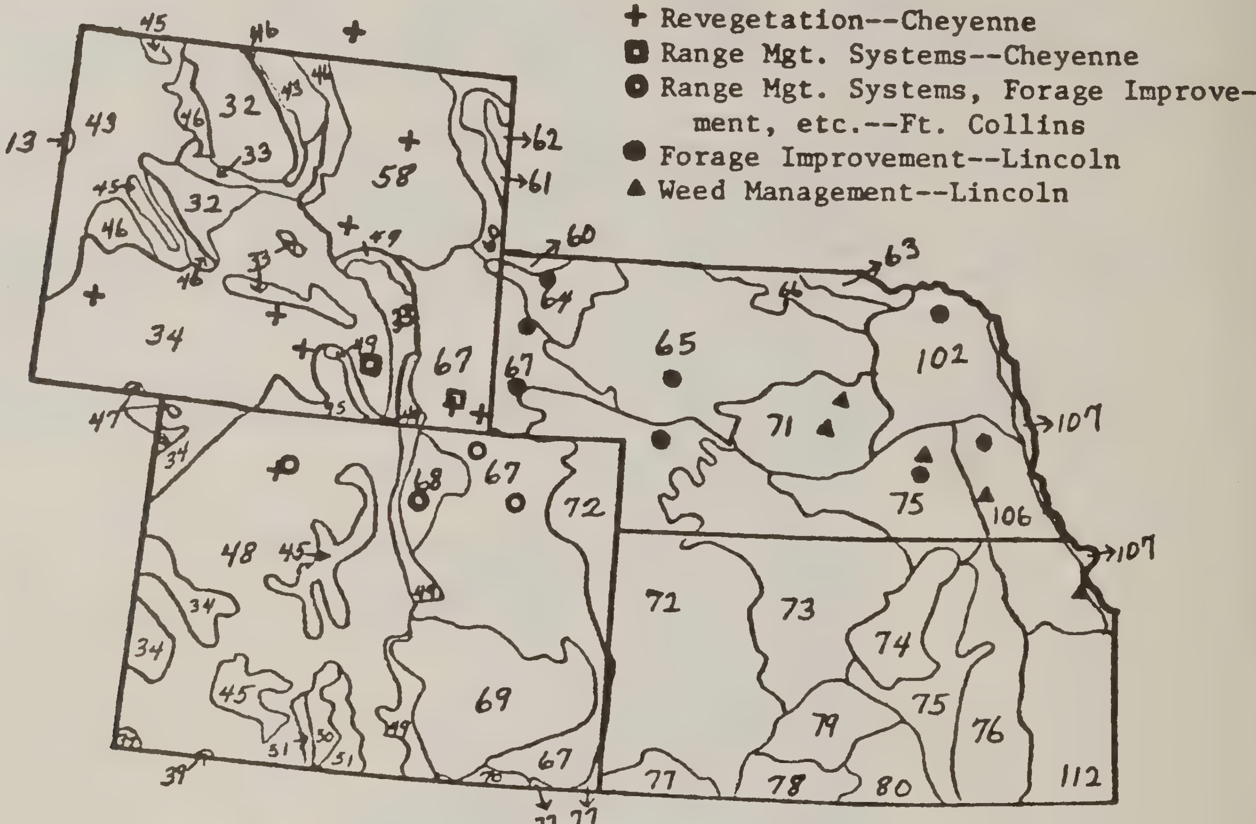
G WESTERN GREAT PLAINS RANGE AND IRRIGATED REGION
- 58 Northern Rolling High Plains
- 60 Pierre Shale Plains and Badlands
- 61 Black Hills Foot Slopes
- 62 Black Hills
- 63 Rolling Pierre Shale Plains
- 64 Mixed Sandy and Silty Tableland
- 65 Nebraska Sand Hills
- 66 Dakota-Nebraska Eroded Tableland
- 67 Central Great Plains
- 68 Irrigated Upper Platte River Valley
- 69 Upper Arkansas Valley Rolling Plains
- 70 Pecos-Canadian Plains and Valleys

H CENTRAL GREAT PLAINS WINTER WHEAT AND RANGE REGION
- 71 Central Nebraska Loess Hills
- 72 Central High Tableland
- 73 Rolling Plains and Breaks
- 74 Central Kansas Sandstone Hills
- 75 Central Loess Plains
- 76 Bluestem Hills
- 77 Southern High Plains
- 78 Central Rolling Red Plains
- 79 Great Bend Sand Plains
- 80 Central Rolling Red Prairies

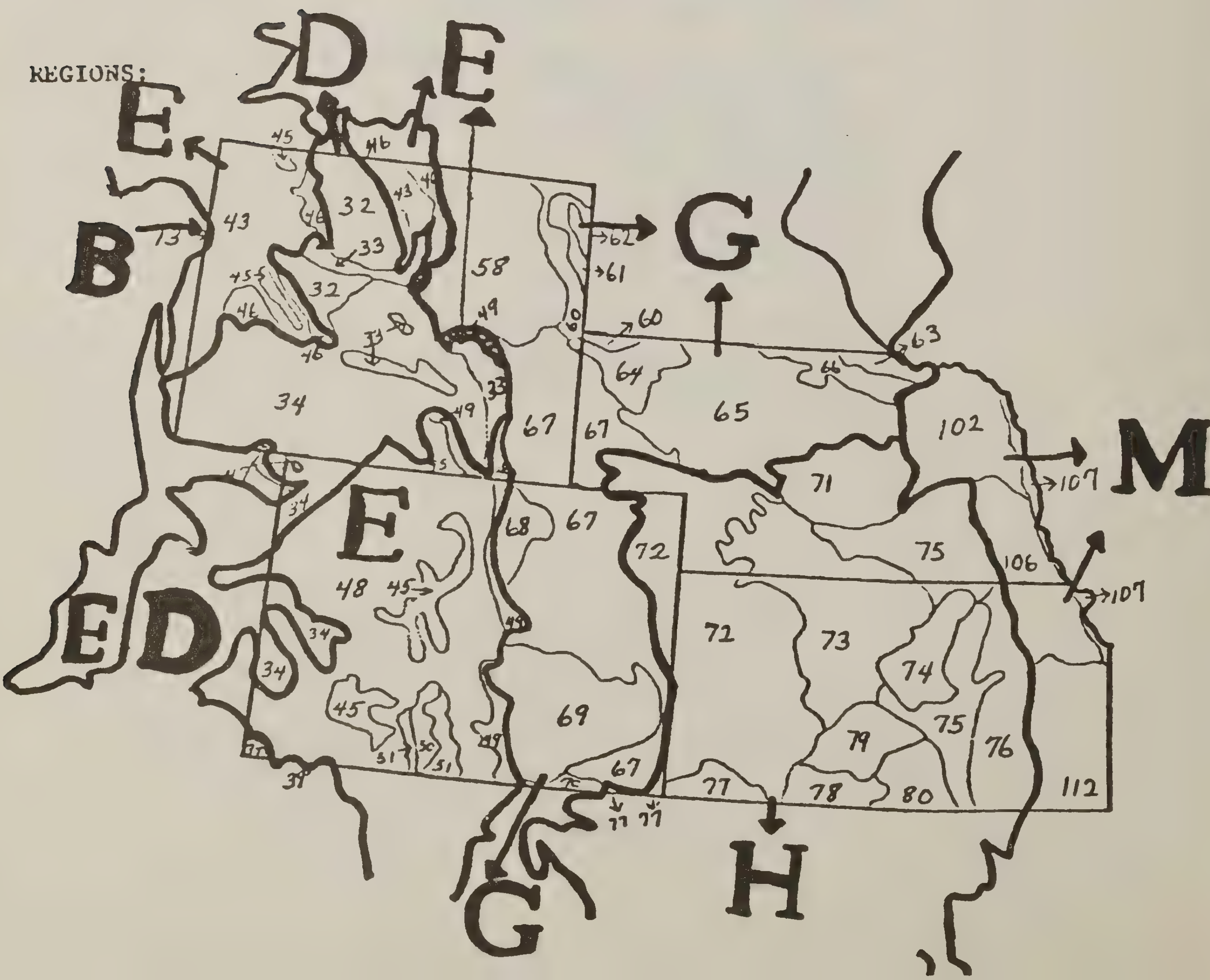
M CENTRAL FEED GRAINS AND LIVESTOCK REGION
- 102 Loess, Till, and Sandy Prairies
- 106 Nebraska and Kansas Loess-Drift Hills
- 107 Iowa and Missouri Deep Loess Hills
- 112 Cherokee Prairies

FIGURE 1: LAND RESOURCE REGIONS AND MAJOR LAND RESOURCE AREAS OF COLORADO, WYOMING, KANSAS AND NEBRASKA.

AREAS:



REGIONS:



Appendix A. Rangeland types, areas, conditions, and stocking in the Northwest Region[1/]

Ecosystem	Area					Condition (US)				Grazed (US)	Stocking Rate (US)	Total Stocking[2/]	
	CO	WY	NE	KS	Total	Good	Fair	Poor	Very Poor			Present	Potential
	-------1,000,000 acres-------					--------------%--------------				%	AUM/a	---1,000 AUM's---	
Plains Grasslands	15.3	20.7	9.7	8.2	53.9	14.7	34.2	39.6	11.5	98	0.294	15,500	51,800
Prairie	1.7	0.0	14.5	8.1	24.3	14.0	34.2	38.1	13.7	95	1.090	25,200	88,000
Mountain Grass-lands	1.4	1.2	0.0	0.0	2.6	17.5	36.2	31.2	15.1	97	0.319	800	2,800
Mountain Meadows	0.4	0.3	0.0	0.0	0.7	32.4	38.8	21.1	7.7	79	0.613	300	900
Wet Grasslands	<0.1	<0.1	0.0	0.0	0.0	17.0	27.6	20.7	34.7	79	0.663	0	0
Sagebrush	7.7	21.0	<0.1	0.0	28.7	12.3	36.1	35.0	16.6	89	0.182	4,600	17,200
Pinyon-juniper	4.4	0.6	0.0	0.0	5.0	9.1	28.6	44.4	17.9	88	0.073	300	1,300
Chaparral-mountain shrub	3.0	0.1	0.0	0.0	3.1	11.8	24.0	37.9	26.3	95	0.125	400	1,700
Desert shrub	0.7	2.1	0.0	0.0	2.8	17.4	36.4	31.5	14.7	70	0.041	100	300
Desert grasslands	0.1	0.0	0.0	0.0	0.1	8.4	24.7	50.5	16.4	93	0.091	<10	30
Hardwoods	3.2	0.5	0.0	0.0	3.7	--	--	--	--	56	0.059	120	240
Ponderosa pine	2.0	1.0	0.2	0.0	3.2	--	--	--	--	74	0.059	140	280
Douglas fir	1.4	1.2	0.0	0.0	2.6	--	--	--	--	52	0.049	70	140
Lodgepole pine	2.2	3.6	0.0	0.0	5.8	--	--	--	--	56	0.011	40	80
Fir-spruce	4.3	2.3	0.0	0.0	6.6	--	--	--	--	51	0.028	90	180
Alpine	0.6	1.6	0.0	0.0	2.2	42.8	27.1	28.7	1.4	70	0.045	70	150
Oak-pine	0.0	0.0	0.0	<0.1	0.0	--	--	--	--	48	0.105	0	0
Oak-hickory	0.0	0.0	0.1	0.7	0.8	--	--	--	--	28	0.253	60	120
Elm-ash--cottonwood	0.0	0.0	0.4	0.5	0.9	--	--	--	--	10	0.213	20	40
Total	48.4	56.2	24.9	17.5	147.0							47,810	165,260

1/ Partially obtained from and based on, "An Assessment of the forest and Range Land Situation in the United States," (Forest Service FS-345, 1980).

2/ Present stocking = (total area) x (% grazed) x (stocking rate). Potential stocking was calculated by assuming that good, fair, poor, and very poor range conditions produced 80, 50, 30, and 10%, respectively, of potential. Based on the ecosystems with condition data, we assumed that the potential stocking for the remaining ecosystems could be doubled.

Appendix B. Livestock and animal units in the Central Plains Region, 1977[1/]

Class of livestock	Number					Animal units[2/]				
	CO	WY	NE	KS	Total	CO	WY	NE	KS	Total
	1,000 head					1,000 units				
Beef cows	889	721	2,082	1,690	5,382	889	721	2,082	1,690	5,382
Replacement heifers	136	127	284	218	765	95	89	199	153	536
Bulls	45	46	104	77	272	56	58	130	96	340
Calves under 500 lb	589	450	1,573	1,418	4,030	236	180	629	567	1,612
Total Cattle	1,659	1,344	4,043	3,403	10,449	1,276	1,048	3,040	2,506	7,870
Ewes	426	827	91	115	1,459	85	165	18	23	291
Wethers and rams	12	32	4	4	52	3	8	1	1	13
Lambs	62	201	15	21	299	6	20	2	2	30
Total sheep	500	1.060	110	140	1,810	94	183	21	26	324
Total						1,370	1,231	3,061	2,532	8,194

1/ From 1977 Agricultural Statistics.
2/ 1 heifer = 0.7 AU; 1 bull = 1.25 AU; 1 calf = 0.4 AU; 1 ewe = 0.2 AU; 1 wether or ram = 0.25 AU; 1 lamb = 0.1 AU.

Appendix C. Estimated numbers of big game in Colorado, Wyoming, Nebraska, and Kansas

Species	Colorado				Wyoming					Nebraska		Kansas		Total number	Total AU
	Plains	Other	Total	AU[1/]	Plains	Desert shrub	Forest	Total	AU	Total	AU	Total	AU		
	(1000 head)			(1000)	(1000 head)				(1000)	(1000)	(1000)	(1000)	(1000)	(1000 head)	(1000)
Elk	0.0	125.0	125.0	83.8	0.0	0.0	63.0	63.0	42.0	--	--	--	--	113.0	125.8
Moose	0.0	0.0	0.0	0.0	0.0	0.0	8.0	8.0	5.3	--	--	--	--	8.0	5.3
Mule deer	0.5	350.0	350.0	87.6	---	---	---	280.0[2/]	70.0	30.0	7.5	8.0	2.0	618.5	167.1
Whitetail deer	0.4	0.0	0.4	0.1	---	---	---	51.0	12.8	50.0	12.5	32.0	8.0	133.4	33.4
Bighorn sheep	0.0	3.0	3.0	0.6	0.0	0.0	3.0	3.0	0.6	--	--	--	--	3.5	1.2
Pronghorn antelope	24.0	8.0	32.0	5.4	87.0	81.0	0.0	168.0	28.6	8.0	1.4	1.2	0.2	205.2	35.6
Feral horses	0.0	1.0	1.0	1.0	---	---	---	10.0	10.0	--	--	--	--	11.0	11.0
Total				114.4					169.3		21.4		10.2		379.4

1/ 1 horse = 1 AU; 1 elk or moose = .67 AU; 1 deer = .25 AU; 1 sheep = .20 AU; 1 pronghorn = .17 AU (Heady, H.F., 1975; Range Management. McGraw-Hill, New York).

2/ In summer and winter, respectively, mule deer distribution (in 1000 head) is 112 and 127 on plains, 98 and 121 on desert shrub, and 70 and 32 in forest.

Appendix D-1. Some potential species for seeding rangelands in the Central Great Plains Region

	Plains[1/]	Prairie[2/]	Mountains and other areas[3/]
Agropyron cristatum, Fairway wheatgrass	x		x
A. dasgstachyum, thickspike wheatgrass			x
A. desertorum, crested wheatgrass	x		x
A. elongatum, tall wheatgrass	x	x	x
A. inerme, beardless wheatgrass			x
A. intermedium, intermediate wheatgrass	x		x
A. riparium, streambank wheatgrass			x
A. sibericum, Siberian wheatgrass	x		x
A. smithii, western wheatgrass	x		x
A. spicatum, bluebunch wheatgrass			x
A. trachycaulum, slender wheatgrass			x
A. trichophorum, pubescent wheatgrass	x		x
Alopecurus arundinaceus, creeping foxtail			x
A. pratensis, meadow foxtail			x
Andropogon gerardii, big sluestem		x	
A. scoparius, little bluestem		x	
Astragalus cicer, cicer milkvetch	x	x	x
Bouteloua curtipendula, sideoats grama	x	x	
B. gracilis, blue grama	x		x
Bromus biebersteinii (B. erectus), meadow brome			x
B. inermis, smooth brome	x	x	x
B. marginatus, mountain brome			x
Buchloe dactyloides, buffalograss	x		
Calamovilfa longifolia, prairie sandreed		x	
Coronilla varia, crownvetch			x
Dactylis glomerata, orchardgrass			x
Elymus canadensis, Canada wildrye		x	
E. cinereus, Basin wildrye			x
E. junceus, Russian wildrye	x		x
Eragrostis trichodes, sand lovegrass	x	x	
Eurotia lanata, winterfat	x		x
Festuca arizonica, Arizona fescue			x
F. arundinacea, tall fescue	x		x
F. idahoensis, Idaho fescue			x
F. ovina, sheep fescue			x
F. ovina duriuscula, hard fescue			x
F. rubra commutata, Chewing's fescue			x
F. thurberi, Thurber fescue			x
Lolium perenne, perennial ryegrass	x		
Medicago sativa, alfalfa	x	x	x
Onobrychis viciaefolia, sanfoin			x
Oryzopsis hymenoides, Indian ricegrass	x		x
Panicum virgatum, switchgrass	x		x
Phalaris arundinacea, reed canarygrass		x	x
Phleum pratense, Timothy			x
Poa ampla, big bluegrass			x
P. pratensis, Kentucky bluegrass		x	x
P. secunda, Sandberg bluegrass			x
Sorghastrum nutans, Indian grass		x	
Sporobolus airoides, alkali sacaton	x		
S. cryptandrus, sand dropseed	x		
Stipa comata, needle-and-thread	x		x
S. viridula, green needlegrass	x	x	x
Trifolium repens, white clover			x

[1/] E. Colorado, E. Wyoming, W. Nebraska, W. Kansas. Lists largely from Merkel et al., 1974.

[2/] W. Kansas, W. Nebraska. Lists largely from Merkel et al., 1974.

[3/] Mountains, high plateaus, intermountain areas, etc., of western Colorado and western Wyoming. List largely from Hull, Hervey, Doran, and McGinnies, 1963.

Appendix D-2. Shrubs potentially useful for planting in the mountains of Wyoming and Colorado[1/]

Scientific name	Common name
Acer grandidentatum	Bigtooth maple
Acer negundo	Boxelder
Amelanchier alnifolia	Saskatoon serviceberry
Amelanchier utahensis	Utah serviceberry
Artemisia abrotanum	Oldman wormwood
Artemisia cana	Silver sagebrush
Artemisia frigida	Fringed sagebrush
Artemisia tridentata	Big sagebrush
Atriplex canescens	Fourwing saltbush
Atriplex gardneri	Gardner slatbush
Berberis repens	Creeping barberry
Caragana arborescens	Siberian peashrub
Ceanothus martinii	Martin ceanothus
Cercocarpus ledifolius	Curlleaf mountain-mahogany
Cercocarpus montanus	Birchleaf mountain-mahogany
Chrysothamnus depressus	Dwarf Rabbitbrush
Chrysothamnus nauseosus	Rubber rabbitbrush
Chrysothamnus parryi	Parry rabbitbrush
Chrysothamnus viscidiflorus	Douglas rabbitbrush
Clematis ligusticifolia	Western virginsbrower
Colutea arborescens	Common bladdersenna
Cotoneaster acutifolia	Peking cotoneaster
Cowania mexicana stansburiana	Stansbury cliffrose
Cupressus arizonica	Arizona cypress
Elaeagnus angustifolia	Russian-olive
Ephedra nevadensis	Nevada ephedra
Ephedra viridis	Green ephedra
Eriogonum heracleoides	Wyeth eriogonum
Eurotia lanata	Common winterfat
Fallugia paradoxa	Apache-plume
Forestiera neomexicana	New Mexican forestiera
Grayia brandegei	Spineless hopsage
Grayia Spinosa	Spiny hopsage
Juniperus scopulorum	Rocky Mountain juniper
Lonicera tatarica	Tatarian honeysuckle
Peraphyllum ramosissimum	Squaw-apple
Potentilla fruticosa	Bush cinquefoil
Prunus fasciculata	Desert peachbrush
Prunus virginiana melanocarpa	Black chokecherry
Purshia glandulosa	Desert bitterbrush
Purshia tridentata	Antelope bitterbrush
Quercus gambelii	Bambel Oak
Rhus glabra cismontana	Rocky Mountain smooth sumac
Rhus trilobata	Skunk bush sumac
Ribes aureum	Golden currant
Ribes cereum inebrians	Squaw currant
Ribes viscosissimum	Sticky currant
Rosa woodsii ultramontana	Woods rose
Salix exigua stenophylla	Gyer willow
Salix purpurea	Purpleosier willow
Salix scouleriana	Scouler willow
Sambucus cerulea	Blueberry elder
Sambucus racemosa pubens microbotrys	Redberry elder
Symphoricarpos longiflorus	Longflower snowberry
Symphoricarpos oreophilus	Mountain snowberry
Syringa vulgaris	Common lilac

[1/] Shrubs from lists for juniper-pinyon, mountain brush, aspen, and associated conifers, subalpine, herbland, and aspen openings in Plummer et al. (1968).

Appendix E. Information available and the need for research for various categories of range science based on a survey of 13 scientists working in the Central Plains in 1978

Item	Category	Research information available[1/]		Research needs[2/]	
		Number of Responses[3/]	Mean	Number of Responses[3/]	Mean
I.	Inventory and Classification	-	(2.3)	-	(3.3)
	A. Census of:				
	1. Vegetation	8	2.5	9	3.0
	2. Forage utilization	9	2.2	9	3.4
	3. Soil stability	9	2.4	9	2.9
	4. Animal populations	6	2.3	7	3.0
	5. Animal movements	5	2.4	7	3.1
	6. Weather	9	2.2	9	2.7
	B. Determination of Range Trends	9	2.0	9	3.9
	C. Site Potential	8	2.1	8	4.2
	D. Assessment of Annual Forage Crops	8	2.1	8	2.9
	E. Land Use	7	2.1	8	3.6
II	Improved Plants	-	(1.8)	-	(4.0)
	A. Germplasm:				
	1. Collection	5	2.2	4	3.8
	2. Preservation	5	2.2	5	3.6
	3. Species relationships	5	1.6	8	3.9
	B. Evaluate Adaptability	10	2.0	9	4.3
	C. Breeding:				
	1. Stress	7	1.9	7	4.7
	2. Photosynthetic efficiency	7	1.7	6	3.0
	3. Quality and quantity	6	1.8	6	4.7
	4. N-fixation	8	1.8	8	4.2
	5. Disease and insect resistance	7	1.7	7	3.4
	6. Water use efficiency	9	1.8	10	4.1
	D. Seed Production	7	1.7	7	4.0
III.	Revegetation	-	(2.1)	-	(3.9)
	A. Availability of Plant Materials	9	2.2	11	3.4
	B. Germination	9	2.2	11	3.6
	C. Seedling Establishment	11	2.0	13	4.3
	D. Methods	12	2.0	12	3.8
	E. Grazing Adaptability	9	1.9	11	4.0
IV.	Ecology, Damage, and Control of Pests	-	(2.2)	-	(3.3)
	A. Unwanted Plants (noxious, poisonous)	5	2.4	6	3.5
	B. Diseases	4	2.0	5	3.4
	C. Nematodes	4	2.0	5	3.8
	D. Insects	4	2.2	6	3.7
	E. Rodents	6	2.3	6	2.7
	F. Rabbits	5	2.4	6	2.7
V.	Other Manipulative Treatments	-	(2.2)	-	(3.3)
	A. Fertilization	9	2.3	9	2.9
	B. Mechanical Treatments (ripping, furrowing, etc.)	9	2.2	10	3.3
	C. Moisture Conservation	9	2.0	11	4.0
	D. Development of Animal Water	8	2.4	9	2.8
	E. Burning	7	2.1	8	3.0

Appendix E. (Continued)

Item	Category	Research information available 1/		Research needs 2/	
		Number of Responses 3/	Mean	Number of Responses 3/	Mean
VI.	Complementary Pastures	-	(2.2)	-	(3.6)
	A. Seasonality	10	2.2	10	3.5
	B. Quantity and Quality	10	2.3	10	3.6
VII.	Grazing Systems	-	(2.1)	-	(3.9)
	A. Proper Utilization	6	2.2	6	3.7
	B. Stocking Rate	6	2.2	6	3.2
	C. Time of Grazing	6	2.2	6	3.8
	D. Native Range Alone	5	2.2	5	3.2
	E. Native Range Plus Complementary Pastures	8	2.0	8	4.1
	F. Native Range Plus Manipulated Range	7	2.0	7	4.1
	G. Manipulated Range	6	2.0	6	4.2
VIII.	Effects of Practices III-VII on:	-	(1.9)	-	(3.8)
	A. Water Quality and Quantity	8	1.9	8	4.0
	B. Moisture Conservation	8	1.9	8	4.0
	C. Erosion and Sedimentation	8	1.9	8	3.4
	D. Range Ecology	6	2.0	6	4.0
	E. Animal Performance and Behavior	6	2.0	6	3.5
IX.	Livestock	-	(2.1)	-	(3.2)
	A. Diet and Nutrition	7	2.3	7	3.4
	B. Performance	6	2.5	6	3.2
	C. Trampling	6	2.0	6	3.3
	D. Behavior	6	1.8	6	2.8
	E. Distribution	5	1.8	6	3.3
X.	Wildlife	-	(1.9)	-	(2.6)
	A. Population	5	2.0	6	2.4
	B. Diet	5	2.0	5	2.6
	C. Habit	5	1.8	5	2.2
	D. Distribution	5	1.8	6	2.6
	E. Wildlife-Livestock Relations	5	2.0	5	3.2
XI.	Basic Range Research	-	(2.0)	-	(4.0)
	A. Plant	8	2.0	9	3.7
	B. Plant-Environment Interactions	10	2.0	11	4.2
	C. Water Use by Plants	10	2.0	11	4.0
	D. Plant-Animal Interactions	7	2.0	7	4.0
	E. N-fixation	9	1.9	10	4.1
XII.	Models	-	(1.9)	-	(3.2)
	A. Analysis				
	1. Prediction	5	2.0	4	2.8
	2. Identification	5	1.8	4	3.3
	3. Detection of research needs	6	1.8	6	4.0
	B. Synthesis or Simulation	4	2.0	6	2.5
	C. Management	5	2.0	5	3.3

1/ Research available: adequate = 3; inadequate = 2; none = 1.
2/ Research need: high = 5; high-medium = 4; medium = 3; medium-low = 2; low = 1.
3/ Number of scientists giving a ranking for this item.

Appendix F. CENTRAL GREAT PLAINS (SY's)

NRP[1/]

Location and Scientist	20110	20100	20170	20280	20750	20760	20770	20780	20810
LINCOLN									
McCarty				1.00(P)					
Vogel		1.00(P)							
CHEYENNE [2/]									
Fairbourn						0.70(P)	0.30(R)		
Hanson	1.00(P)								
Hart	0.80(P)	0.10(R)				0.10(R)			
Booth							1.00(P)		
Schuman	0.10(R)					0.30(R)	0.60(P)		
LARAMIE									
Rauzi						0.50(P)	0.50(R)		
FORT COLLINS[3/]									
Bowman	0.50(P)								
Laycock	1.00(P)								
McGinnies	1.00(P)								
Shoop	1.00(P)								
Townsend	0.40(R)	0.60(P)							
Wilson	0.80(P)	0.10(R)	0.10(R)						
TOTAL	6.60	1.80	0.10	1.00	--	1.80	2.40	--	--
							GRAND TOTAL		13.50

[1/]P = primary; R = related.

[2/]Does not include support scientists Dean (agronomist) and Samuel (botanist); division of their research is similar to Hart's.

[3/]Does not include support scientist Mueller (range scientist); entire efforts in

Appendix G. CENTRAL GREAT PLAINS (SY's)

RANGE RESEARCH[1/]

Location and Scientist	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
LINCOLN												
McCarty				1.00								
Vogel		1.00										
CHEYENNE[2/]												
Fairbourn			0.15		0.25	0.50		0.10				
Hanson							0.50					0.50
Hart	0.10					0.20	0.50					0.20
Howard			0.70					0.30				
Schuman			0.30	0.10	0.20			0.40				
LARAMIE												
Rauzi					0.50			0.50				
FORT COLLINS[3/]												
Bowman			0.25		0.10			0.15				
Laycock				0.20				0.50			0.30	
McGinnies			0.70		0.20			0.10				
Shoop				0.35			0.10	0.25	0.30			
Townsend		0.70									0.30	
Wilson		0.25	0.25								0.50	
TOTAL	0.10	1.95	2.35	1.30	1.60	0.70	1.10	2.30	0.30	--	1.10	0.70
										GRAND TOTAL		13.50

[1/]See attached.

[2/]See footnote 2, Appendix F; Dean's research is 0.2 III, 0.6 V, and 0.2 VI; Samuel's is 0.6 I, 0.2 III, and 0.2 V.

[3/]See footnote 2, Appendix F. Mueller's research is split the same as McGinnies.

Appendix G. (Continued)

CENTRAL GREAT PLAINS (SY's)

ECOSYSTEMS[1/]

Location and Scientist	A	B	C	M	N
LINCOLN					
McCarty	0.40	0.60			
Vogel	0.50	0.50			
CHEYENNE[2/]					
Fairbourn		0.80	0.20		
Hanson		0.90	0.10		
Hart		1.00			
Howard		0.70	0.30		
Schuman		0.70	0.30		
LARAMIE					
Rauzi		0.50	0.50		
FORT COLLINS [3/]					
Bowman		0.50			
Laycock		1.00			
McGinnies		0.70	0.10	0.10	0.10
Shoop		1.00			
Townsend		1.00			
Wilson		1.00			
TOTAL	0.90	10.90	1.50	0.10	0.10
					GRAND TOTAL 13.50

[1/] A = Prairie grassland   M = Mountain grasslands
B = Plains grasslands   N = Chaparral-mountain shrub
C = Sagebrush

[2/] See footnote 2, Appendix F.

[3/] See footnote 3, Appendix F.

Appendix H.

CENTRAL GREAT PLAINS (SY's)

RANGE RESEARCH[1/]

Location and Scientist	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
LINCOLN												
McCarty				1.00								
Vogel		1.00										
CHEYENNE[2/]												
Fairbourn			0.15		0.25	0.50		0.10				
Hanson							0.50					0.50
Hart	0.10					0.20	0.50					0.20
Booth			0.70					0.30				
Schuman			0.30	0.10	0.20			0.40				
LARAMIE												
Rauzi					0.50			0.50				
FORT COLLINS [3/]												
Bowman			0.25		0.10			0.15				
Laycock				0.20				0.50			0.30	
McGinnies			0.70		0.20			0.10				
Shoop				0.35			0.10	0.25	0.30			
Townsend		0.70									0.30	
Wilson		0.25	0.25								0.50	
TOTAL	0.10	1.95	2.35	1.30	1.60	0.70	1.10	2.30	0.30	--	1.10	0.70
												GRAND TOTAL 13.50

[1/] See attached.

[2/] See footnote 2, Appendix F; Dean's research is 0.2 III, 0.6 V, and 0.2 VI; Samuel's is 0.6 I, 0.2 III, and 0.2 V.

[3/] See footnote 2, Appendix F. Mueller's research is split the same as McGinnies.

Appendix I. Research teams needed top meet research needs in the Central Plains Region.

RESEARCH TEAM, LOCATION, AND TYPES OF SCIENTISTS NEEDED	SEA (NO.)	Coop.	Not Present	Potential for adding to team: Hire	Transfer	Coop. other SEA units	COOPERATORS: Univ.	State	Fed.	Unknown	Comments
A. REVEGETATION (Strip mine rehab)											
Cheyenne and Laramie											Closer coordination with Woolhiser's work on hydrology of strip-mined areas is needed.
1. Soil Scientist (Schuman)	1.0										
2. Soil Scientist (Rauzi)	1.0										
3. Soil Scientist (Fairbourn)	1.0										
(Water Conservation)											
4. Range Scientist (BOOth)	1.0										
5. Plant Physiologist (vacant)			x							x	
6. Agricultural Engr (vacant)			x	x							
B. RANGE MANAGEMENT SYSTEMS (Plant-animal relations and management systems)[1] Ft. Collins and Cheyenne											
1. Range Scientist (Laycock)	1.0										Close coordination between work at Ft. Collins and Cheyenne is essential.
2. Agronomist (Hart)	0.5										
3. Range Nutri (Cheyenne vacant)		x									
4. Range Nutri (Ft. Collins vacant)			x				x				
5. Range Animal Sci (Shoop)	1.0										
6. Modeler(s) (Hanson	1.0						x				
7. Economist (vacant)			x						x		
C. WATERMANAGEMENT AND PLANT-SOIL-WATER RELATIONS. Ft. Collins											
1. Plant Physiologist (Wilson)	1.0										Greater cooperation with soil-water units at Ft. Collins and Akron is needed.
2. Range Scientist (McGinnies)	.5										
3. Soil Scientist (Bowman)	.5										
4. Hydrologist (vacant)			x			x					

[1] SY's do not include botanist and agronomist support scientists at Cheyenne and a support range scientist at Ft. Collins.

Appendix I. Continued.

RESEARCH TEAM, LOCATION, AND TYPES OF SCIENTISTS NEEDED	SEA (NO.)	Coop.	Not Present	Potential for adding to team: Hire	Transfer	Coop. other SEA units	COOPERATORS: Univ.	State	Fed.	Unknown	Comments
D. FORAGE IMPROVEMENT - Ft. Collins											
1. Geneticist (Legume)	1.0										
2. Geneticist (Grass)		x			x						
3. Plant Physiologist			x			x					
4. Range Sci./Agronom.			x			x					
E. FORAGE IMPROVEMENT - Lincoln											
1. Geneticist (Grass)	1.0		x								
F. HIGH ELEVATION RANGELANDS (Revegetation, management) High-Elevation Distrubed Areas (Ft. Collins)											Phase out McGinnies's work on the plains and concentrate on high-elev. revegetation work.
1. Range Scientist	.5										
Mountain Meadows (Cheyenne)											
1. Range Scientist/Agronomist	.5										
2. Modeler			x	x							
G. WEED MANAGEMENT - Lincoln											
1. Agronomist	1.0										
2. Entomologist			x							x	

[1] SY's do not include botanist and agronomist support scientists at Cheyenne and a support range scientist at Ft. Collins.

REPORTS IN THIS SERIES

Evans, R. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Great Basin and Northwest. 1980. SEA-AR range research in the Great Basin and Northwest (Idaho, Nevada, Oregon, Utah, and Washington). Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

Herbel, C. H., P. L. Sims, W. A. Laycock, R. J. Lorenz, R. A. Evans, K. G. Renard, SEA-AR Rangeland Scientists in the 17 Western States, R. F Barnes, and G. E. Carlson. 1980. Range research, an assessment of current problems and a strategy for the future: A summary of range research by SEA-AR in the 17 western states. Agricultural Research, Science and Education Administration, U. S. Department of Agriculture. 18 pages.

Laycock, W. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Central Great Plains. 1980. SEA-AR range research in the Central Great Plains (Colorado, Kansas, Nebraska, and Wyoming). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Lorenz, R. J., J. R. Wight, R. J. Kartchner, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Northern Great Plains. 1980. SEA-AR range research in the Northern Great Plains (Montana, North Dakota, and South Dakota). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Renard, K. G., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southwest. 1980. SEA-AR range research in the Southwest (Arizona, California, and New Mexico). Agricultural Research, Science and Education Administration, U. S. Deparment of Agriculture.

Sims, P. L., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains. 1980. SEA-AR range research in the Southern Great Plains (Oklahoma and Texas). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

SEA-AR Range Research Assessment

Southern Great Plains

United States Department of Agriculture
Science and Education Administration
Agricultural Research

RANGE RESEARCH

An Assessment of Current Problems

and

A Strategy for the Future

SOUTHERN GREAT PLAINS

Oklahoma, Texas

Prepared by

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CONTENTS

SEA-AR RANGE RESEARCH IN OKLAHOMA-TEXAS

(Southern Great Plains)

I. Situation

A. The Resource:

The Southern Plains rangelands, dominated by warm-season plants ranging from bluestem-grama-buffalo grass on the north to coastal prairie and forested rangeland types on the south and intermixed with productive winter wheat, cotton, feed grains, and farmed forage-producing lands, is characterized by a wide range of soils and variable climate (Fig. 1). The Major land resource regions include the southern half of the Central Great Plains Winter Wheat and Range Region, Southwestern Plateaus and Plains Range and Cotton Region, and the Southwestern Prairies Cotton and Forage Region. The region is dissected by several major stream channels which play an important role in the region's agriculture; the major streams are the Arkansas, Cimarron, Canadian, Red, Brazos, Trinity, Llano, Colorado, Guadalupe, Pecos, and Rio Grande.

Principal rangeland types in the Southern Plains are the plains grassland, prairie, desert shrub, shrub-steppe, Texas savanna, and oak-hickory (Appendix A). A major share of these lands is in fair to poor condition with carrying capacities ranging from 0.03 to over one AUM per acre.

Average annual precipitation, varying from less than 15 inches on the west to over 45 inches on the eastern edge, is punctuated by frequent droughts, and plants are stressed annually by high evaporative losses from soils which range from shallow, frail, and erodible to deep, fertile, and stable. Typical plants of these rangelands are adapted to survive climatic extremes and herbivory, but are generally low in productivity. Forage production is more reliable in the subhumid to humid eastern parts of Texas and Oklahoma, but even here, seasonal moisture stress is a major factor limiting forage production.

The vegetation, although highly variable throughout the Southern Plains, is dominated by warm-season perennial grasses with, oftentimes, an overstory of undesirable tree or shrub species. Dominant species throughout the region are listed with the Mission statements for each location. There also exists a wide array of forbs which contribute the character and usefulness of the numerous range sites in the Southern Plains.

Improved varieties of native and introduced forage grasses have enhanced rangeland production potential (Appendix D). However, seed supplies are often limited or nonexistent. For range improvement to succeed on a large scale, propagules of improved plant material must be available in adequate supplies and the economic climate favorable for cost-effective implementation.

Beef cattle production, from almost 20 million head, is the major use of

about 135 (63 percent) of the 212 million acres of rangeland in the Oklahoma-Texas area (Appendix B). In the Southern Plains, particularly in Texas, sheep (2.5 million) and goats (1.1 million), along with relatively large nubmers of game animals, are significant users of this renewable resource (Appendix C). These land resources, producing at an estimated 50 percent of their potential, currently yield about 35 million animal unit months of grazing (Appendix A). Water production, recreation, and aesthetic values represent other principal values of this region's resources.

B. The Research:

Rangelands in the Southern Plains, typical of those found in southwestern Kansas, southeastern Colorado, and western New Mexico, as well as in the Oklahoma-Texas area, can be markedly improved in the amount of solar energy captured and transfered to bound energy and to products usable by man. The needs are apparent, and the opportunities exist to develop principles of range ecosystem management to increase red meat production through improved grazing systems, development of, and cultural practices for, improved forage species and varieties of legumes for native and improved rangelands, synchronization of animal genetic potential with the rangeland environment, and increasing precipitation-use efficiency consistent with conservation of soil, water, aesthetic, and energy resources.

The following statements outline the critical research problems facing scientific personnel in the Southern Plains:

*Management Systems: Historically, coordinated research encompassing the many disciplines required to develop practical management strategies has been lacking. Rangeland users are faced with climate, soil, vegetation, animal, and economic problems and all of their interrelationships. Research programs must address this myriad of problems if the results of our efforts are going to be applicable to optimizing the utilization of the water, energy, and nutrients transferred through range ecosystems and to improve cultural energy and economic efficiency of rangeland production units.

*Forage Improvement-Revegetation: Vast areas are essentially bare, seriously depleted, or covered with either useless or unproductive vegetation. There remains a critical need for high quality forage species and cultivars (grasses, forbs, legumes, and shrubs) for revegetation of these areas and for technology to successfully establish and manage these species under range conditions.

*Brush and Weed Management: Current and future environmental constraints on the use of existing pesticides and the continuing encroachment of undesirable plants on range ecosystems require continued emphases on the development of new and safer pesticide formulations and application techniques and

strategies. Biological control systems must be evaluated to determine their utility for controlling undesirable plants.

*Water Management: Water is a valuable, often scarce, rangeland resource product. It is imperative that the impact of range management strategies on water yield and quality be evaluated.

*Soil-Plant-Water Relations: Increasing precipitation-use and nutrient cycling efficiency are fundamental to enhancing the productivity of rangeland ecosystems. Overcoming the inherently low productivity of rangelands requires understanding of the relationships between above- and below-ground primary productivity and soil water and nutrient availability.

*Primary Productivity: Increasing the efficiency of solar energy capture and the transfer of bound energy into useful products by man while minimizing energy losses through nonproductive pathways is dependent upon a thorough knowledge of the relationship of the dynamics of range ecosystem structure, above- and below-ground, to environmental conditions and stresses and range management strategies. Such information is prerequisite to the development of range ecosystem management principles.

II. Problems and Trends

While there are variations in physiography, vegetation, soils, climate, and land uses throughout the Southern Plains, there are similarities in the problems and trends of range resource management and utilization throughout this region. Consequently, the following lists are generalized for the entire area. There are differences in emphases as these problems and trends are evaluated for the specific conditions occurring on diverse rangeland types. (Lewis (1973) has provided an important review of the general trends influencing agriculture in the coming decade, some of which are included below.

A. General Problems and Trends:

1. Native rangelands are inherently low in productivity, currently yielding at less than 50 percent of potential, and exhibit marked annual variations in response to climate and past use.

2. Because of the low inherent productivity of native rangelands (based on present "state-of-the-art") economic returns from many range improvement practices do not warrant their use unless applied at a sufficiently large scale to offset high interest costs. Almost all rangelands in the Southern Plains are in private ownership, and consequently, range improvement

practices must be cost-effective.

3. Environmental constraints restrict the use of some herbicides for which no suitable alternatives are presently available.

4. There is continued economic pressure to convert lands utilized for range and other annual forage crops to food grain production and urban and industrial development.

5. Fossil energy will continue to cost more because of increased scarcity. Consequently, some irrigated lands now in crop production may be reverted to rangeland with attendant revegetation problems.

6. There will be increasing economic pressures to maximize water yields from rangeland watersheds for downstream municipal and industrial uses. Consequently, new and improved forage species must have reduced water requirements.

7. More than a dozen major brush species infest approximately 102 million acres in Oklahoma and Texas. This brush and weed complex results in reduced forage yields, diminished livestock production, increased livestock management costs and lessened water yields, while erosion from rangeland watersheds is increased.

8. Lack of knowledge and understanding of the total dynamics of range ecosystem structural components, both above- and belowground, results in rather imprecise or inadequate investigations into management practices.

9. Continuing increases in the ratio of debts to assets are a source of major concern for all farmers and ranchers as well as various lending institutions. This trend is particularly disturbing for the younger segments of the farmer-rancher population.

B. General Trends

1. World population will continue to grow, resulting in a greater demand for U.S. food products, particularly grains and red meat.

2. Industrial growth in developed and developing nations results in high standards of living, hence greater demands on scarce nonrenewable resources--fossil energy, water, and land--while contributing to environmental pollution.

3. Industrial development will provide new technologies and sophisticated equipment and materials to enhance agricultural enterprise management.

4. Future research on rangelands for red meat production should emphasize economical efficiency and conservation of land resources minimizing: (1) the use of feed suitable for humans, (2) scarce nonrenewable resources, and (3) conflicts with other uses of the resources.

5. There will be a reconversion of land to range as scarce water, high energy costs, and other factors make irrigation and dryland cropping uneconomical.

6. Arable cropland now used to produce forages and feed grains for livestock will gradually be used to produce human foods. Consequently, rangelands will become more important in the total picture of red meat production and will result in increased emphasis on methods of increasing the productivity of rangelands.

7. Increased conversion of rangeland into urban and other uses.

C. Specific Problems

1. There is an inadequate array of cool season plants suitable for livestock grazing during the winter period in much of the Southern Plains.

2. There is a lack of improved native or exotic legumes for "self-fertilization" of native rangelands and improved pasture species.

3. There is a lack of studies to integrate improved pastures and annual forages with native rangeland into beef production systems.

4. Inability to predict rangeland productivity and establish stocking rates that reflect variable forage production.

5. Inefficient water-use by native range plants, which contributes to low productivity, high runoff, and soil erosion.

6. Lack of cost efficient water conservation and harvesting practices.

7. Lack of knowledge about below-ground herbivores, small herbivores, plant diseases, and insects which affect forage production and range plant "vigor."

8. Lack of appropriate biological and chemical controls for major weed and brush species.

III. Researchable Problems and Goals

The science of range management is a complex of disciplines related to natural and man-modified resources and management acumen. Greatest potentials for breakthrough in improved range management are most likely to occur from multidisciplinary research efforts that involve scientists working in concert with coordinated objectives and methodology on research projects that increase our understanding of range ecosystem structure, function, and utilization. Systems research should be supported by the necessary disciplinary efforts to fill critical research voids. The ultimate goal for rangeland resources research should be to gain an adequate understanding of range ecosystem structure and function that permits the development of management strategies to optimize the flow of energy and nutrients into marketable products while maintaining functional and stable ecosystems and economical farming and ranching units.

The goals of optimizing the production of quality red meat from rangeland and related natural resources at economical prices commensurate with conservation of land as a renewable resource while minimizing the use of feeds suitable for human foods, scarce nonrenewable resources and conflicts with other resource uses is irrevocably tied to the concepts of biological and economical efficiency of production. Consequently, inputs and subsidies to biological production systems must be economically evaluated in any future resource management strategies. Fossil energy will no longer be a low cost input, particularly if it is biologically inefficient.

A. Research Needs:

Each scientist working in the Southern Plains on range or related research was asked to evaluate range research needs in 12 categories. The "weighted rating" for each of the categories is given in Appendix E for both the availability of needed information and the need for research. Based on this survey, a prioritized list of research needs for the respective range research categories are:[1/]

Priority	Category	Rating
1.	Basic range research	4.8
2.	Complementary pastures	4.5
3.	Revegetation	4.4
4.	Models	4.3
5.	Effects of practices	4.1
6.	Grazing system	4.0
7-8.	Improved plants	3.9
7-8.	Ecology, damage, and control of pests	3.9
9.	Livestock	3.7
10.	Other manipulative treatments	3.4
11.	Inventory	3.2
12.	Wildlife	3.1

[1/] Research need: high = 5; high-medium = 4; medium = 3.

Synthesis of the questionnaire data indicate the following high priorities:

1. There is a need for basic research on plants in relationship to withstanding stress of limited water and other environmental factors and their use by herbivores.

2. The development of forage-livestock management systems that optimize land resource uses is needed.

3. There is a continuing need to develop improved plant materials for increased quantity and quality of forage for domestic and wild herbivores, land resource conservation, and aesthetics.

4. Grazing systems need to be developed to improve the vast native range resource, producing at less than one-half of its potential, and to improve the economic stability of the ranching industry.

5. Grazing systems need to be developed to optimize native range and complementary forage management systems.

6. Revegetation methods need to be refined to assure greater success of establishment of stands of improved plant materials including complex mixtures of grasses, forbs, shrubs, and legumes.

7. Modeling techniques should be used to (a) develop predictive equations from research data, (b) provide analyses of research priorities and objectives, and (c) serve as a framework for assembling research results from multidisciplinary, interdisciplinary, and disciplinary investigations into management strategies.

Within the system's framework, the following is a list of specific researchable problems for the Southern Plains. These have been assembled according to the traditional topics with more specific problems identified in each research area.

1. Forage improvement:

    a. Development of grass, forb, and browse (including legumes) species and varieties for revegetation efforts and for complementary pastures (dryland, augmented precipitation, e.g., water spreading, irrigation, etc.) for use in management systems with rangelands.

    b. Development of techniques for efficient and effective evaluation of germplasm required in variety development and determination of adaptation. Characteristics requiring new or improved techniques include establishment, drought resistance, winter-survival ability, forage

quality, resistance to abusive management, and adaptation to specific soil conditions.

c. Development of techniques for evaluation of agronomic and range potential of species and new varieties of forage plants.

d. Development of new breeding techniques, such as tissue culture, for use on range plants.

e. Increased understanding of the physiological basis for seed dormancy in forage grasses to determine its hinderance or advantage to stand establishment.

f. Basic research on control of partitioning of seed reserves between root and shoot in the germinating seedling, especially in regard to possible genetic manipulation of this partitioning to enhance seedling establishment.

g. Basic research relative to the subcellular and cellular basis of heat and desiccation tolerance in leaves with the objective of defining heritable genetic components which could be incorporated into superior lines.

h. Determination of Kleingrass' involvement in photosensitization of sheep and goats.

i. Determination of forage intake, digestibility, animal performance, and management of improved forages.

2. Management systems:

   a. Evaluate multiple-use value of rangeland, emphasizing livestock production commensurate with recreation, wildlife, and watershed values.

   b. Develop range enterprise management strategies that optimize red meat production by integrating land resource, animal, and resource management factors using an holistic approach.

   c. Develop forage and beef production systems to produce slaughter-weight animals using forage and feeds not used by humans.

   d. Develop and evaluate grazing schemes that consider plant morphology and physiology and plant community dynamics as well as the nutrient requirement of large herbivores.

3. Revegetation:

   a. Development of guidelines for identifying site potentials

for revegetation relative to mineral nutrient availability including improvement and/or recalibration of soil chemical test procedures for predicting nutrient supplying capabilities.

b. Determination of the mineral nutrient requirements (macro and micro) which are critical to the establishment and persistence of various forage grasses under severe water and temperature stress environments.

c. Development of revegetation system models to implement improved techniques of seeding, fertilizer use, water management, and grazing practices incorporating overall resource utilization and conservation objectives.

d. Determination of water and temperature requirements of forage plants during germination and seedling development.

e. Develop automatic machinery to fabricate bandoleered plugs, raise seedlings in controlled environment facilities, and plant seedling plugs in the field.

f. Evaluate herbicides required to keep weeds under control until seedlings are established.

4. Brush and weed management:

a. Investigate growth responses of rangeland brush, weed, and forage species to herbicides under controlled environmental conditions.

b. Develop an understanding of the physiological life history of major rangeland brush and weed species.

c. Develop and evaluate improved herbicide formulations for better placement, controlled release, and greater effectiveness.

d. Investigate the fate of new herbicides and new formulations of established herbicides in rangeland brush and weeds and in important range and pasture species.

e. Determine ways to enhance the absorption, penetration, and translocation of new herbicides and herbicides in new formulations.

f. Determine the effect of herbicide treatment upon physiological and biochemical processes in brush and forage species.

g. Determine the extent of allelopathy in rangeland weeds and forage species.

h. Investigate the fate of herbicides in rangeland soils, plants, and water with particular reference to reduction of nonpoint source pollution and improvement of water quality.

i. Develop integrated methodology for control of rangeland brush and weeds (integrated pest management approach).

j. Improve methods for range brush and weed assessment and survey.

k. Investigate the autecology, phenology, morphology, and physiology of brush and weed species.

l. Determine the basis for enhancement of weed and brush response to soil active herbicide applications following top removal (burning, seeding, etc.).

m. Development of acceptable ground and aerial equipment for uniform and accurate distribution of soil-applied pelleted herbicides.

n. Study the utility of biological control on five brush species (mesquite, creosotebush, tarbush, baccharis, and whitebrush) and five species of poisonous weeds (perennial broomweed, bitterweed, threadleaf groundsel, African rue, and locoweed).

5. Water management:

a. Develop new and innovative ways to use rainfall and runoff to increase forage production and to improve soil and water conservation by standard practices, e.g., water spreading, pitting, etc.

b. Determine the hydrologic effects of removing brush and other noneconomic plants from rangelands by either mechanical or chemical means.

c. Quantify infiltration on rangelands as affected by soils, vegetation type and density, and grazing intensity, and determine the impact of improved plant materials and range ecosystem management strategies on water and soil economy.

d. Determine the hydrologic and water quality effects of converting an area from cropland to rangeland.

e. Model the mechanism of herbicide movement from watersheds and within stream systems as a function of herbicide chemistry, soil characteristics, watershed characteristics, and climate.

f. Develop models which express, mathematically, the effects of management practices, climatic variables, and basin characteristics on runoff, sediment yield, water quality, and forage production to aid decision makers in rangeland management.

6. Plant-soil-water relations:

   a. Develop improved fertilizer management practices to optimize forage grass production and quality through adapting technology available for other cropping systems to the range ecosystem.

   b. Quantify nutrient cycling (particularly for N and P) in permanent (long-term) improved forage grass stands under semiarid climates as a basis for managing nutrient input.

   c. Develop leguminous plant materials that will grow in native or rehabilitated plant communities and enhance the nitrogen status of range soils.

7. Plant-animal relationships:

   a. Determine the nutritive value of range and pasture forage by major species in the diet of grazing animals by season of year and plant phenology on the major range sites in the Southern Plains.

   b. Develop criteria for supplementation of range animals during periods when the nutritive value of forage does not meet animal requirements for various production phases.

   c. Determine beef production value of new plant materials under grazing.

   d. Determine stand longevity of new plant materials under grazing.

   e. Evaluate appropriate grazing systems for new plant materials to provide data-base for range-pasture resource management strategies.

   f. Determine the interaction between the range ecosystem environment and type of animal used in the red meat production system.

   g. Study the etiology of plant toxicoses, identify the poisonous principles and mechanisms of action, and devise methods for the prevention of intoxification of animals by plants.

8. Remote sensing:

   a. Investigate the use of remote sensing techniques to identify plant communities, determine presence of undesirable species, and monitor vegetation changes as influenced by management regimes, improvement practices, and weather conditions.

   b. Develop mathematical models with imagery and digital data inputs to predict harvestable forage or animal carrying capacity of rangeland.

B. Research Teams

Table 1 outlines the scientific composition of each of the eight range research teams as developed at the Range Research Planning meeting in Las Cruces, New Mexico in November, 1978. It is assumed, for practical purposes, that the minimum level for each type of scientist on each team would be one SY. It is probable that some scientists would have joint responsibilities in more than one research area. For many types of scientists, because of the research needs and because of the nature of the research, greater than one SY input per team is required. More details on present and recommended levels of SY's are given in Table 2 and in the sections on Current Research Effort (IV) and Recommendations (VI).

Table 1. Scientific composition of the proposed research teams to meet recommended goals of the Oklahoma-Texas Area, Southern Plains Region.

1. FORAGE IMPROVEMENT
   1. Agronomists
   2. Plant geneticists
   3. Range scientists
   4. Animal nutritionists

2. MANAGEMENT SYSTEMS
   1. Range scientists
   2. Agronomists
   3. Plant physiologists
   4. Synecologist (Plant community ecologist)
   5. Soil scientists
   6. Agricultural engineers
   7. Biologists

3. REVEGETATION
   1. Soil scientists
   2. Plant geneticist
   3. Plant physiologists
   4. Agricultural engineers
   5. Range scientists
   6. Agronomists

4. BRUSH AND WEED MANAGEMENT
   1. Plant physiologists
   2. Agronomists
   3. Agricultural engineers
   4. Entomologists
   5. Range scientists
   6. Plant pathologists
   7. Ecologists
   8. Chemists

5. WATER MANAGEMENT
   1. Soil scientists
   2. Agronomists
   3. Agricultural engineers
   4. Hydraulic engineers
   5. Geologists
   6. Microbiologists
   7. Range scientists

6. SOIL-PLANT-WATER RELATIONS
   1. Soil scientists
   2. Agricultural engineer
   3. Agronomists
   4. Range scientists
   5. Plant physiologists

7. PLANT-ANIMAL RELATIONS
   1. Range scientist
   2. Animal scientist
   3. Agronomists

8. REMOTE SENSING
   1. Range scientists
   2. Soil scientists
   3. Agricultural engineer
   4. Agronomists

IV. Current Research Effort

A. Research Locations:

Range management research is underway at eight SEA-AR locations in the OTA, Southern Plains Region. Work is being conducted at more than 40 worksites in about five land resource regions on some nine resource areas. Rangeland is a primary resource with both irrigated and dryland farming major associated land uses.

Elevation ranges from 300 to 5,000 feet across the worksites on which the various types of range investigations are conducted. Climatic features at the major locations include: precipitation 15 to 50 inches, temperature 55 to 70° F, and frost-free period varying from 180 to 320 days.

A brief description of the mission, resource, features, objectives, status, plans, and opportunities and needs are detailed in this section for each of the OTA locations involved in range and related research.

The range research locations are:

1. Southwestern Great Plains Research Center, Bushland, TX.
2. Texas A&M University, College Station, TX.
3. Southern Plains Watershed and Water Quality Laboratory, Durant-Chickasha, OK.
4. Southwestern Livestock and Forage Research Station, El Reno, OK.
5. Forage Seed Technology Research, Stillwater, OK.
6. Grassland-Forage Research Center, Temple, TX.
7. Soil and Water Conservation Research, Weslaco, TX.
8. Southern Plains Range Research Station, Woodward, OK.

<u>Southwestern Great Plains Research Center, Bushland, TX</u>.

1. Worksites: Dalhart, TX.

   a. <u>Mission</u>:

   Improve forage production through improved management practices including introduction of new species, plant nutrition, and water conservation.

   b. <u>Land Resource Region and Area (Austin, 1972)</u>:

   Central Great Plains Winter Wheat and Range Region (H)

Southern High Plains (77)

Land Use: 40% rangeland
60% dry farmed and irrigated

Elevation: 2,500 to 5,000 feet

Soils: Ustolls and Ochrepts[1]

c. Climate (Average):

Precipitation: 15 to 23 inches, highest late spring through autumn

Temperature: 55° to 60° F

Frost-free period: 180 to 220 days

d. Ecoregion: Dry steppe, Great Plains Shortgrass Paririe

e. Ecosystems:

Plains grasslands

f. Potential Natural Vegetation and Major Plant Species Kuchler, 1964):

Grama-buffalo grass:

Bouteloua gracilis, blue grama
Buchloe dactyloides, buffalo grass

Others:

Agropyron smithii, western wheatgrass
Aristida purpurea, purple three-awn
Bouteloua curtipendula, side oats grams
Bouteloua hirsuta, hairy grama
Gaura coccinea, scarlet gaura
Grindelia squarrosa, curlycup gumweed
Haplopappus spinulosus, false broomweed
Lycurus phleoides, wolftail (Texas timothy)
Muhlenbergia torreyi, ring muhly (ringgrass)
Countia spp. (southern part), pricklypear
Plantago purshii, wooly indianwheat
Psoralea tenuiflora, scurf-pea
Ratibida columnifera, prairie coneflower
Senecia spp., groundsel
Sitanion hystrix, bottlebrush squirreltail
Sphaeralcea coccinea, scarlet globemallow
Sporobolus cryptandrus, sand dropseed
Yucca galuca, small soapweed
Zinnia grand flora, zinnia

[1] Soil terminology follows: Aanhdahl, A. R. 1972. Soils of the Great Plains, NE Agric. Expt. Sta., Lincoln, NE.

g. Objectives:

(1) Evaluate the persistence of grass species previously introduced into the region.

(2) Determine forage quality of several native and introduced grass species.

h. Status:

(1) Grass plantings made near Dalhart, Texas in 1942 have been evaluated for botanical composition and ground cover.

(2) Six grass species from the Dalhart plantings are being sampled monthly to determine their relative quality and their change in quality during the growing and grazing season.

i. Plans: Current plans are indefinite beyond completion, summarization, and publication of the work in progress.

j. Opportunities and Needs: Some of the major range research needs (priority for Bushland Area) are:

(1) Forage improvement

(2) Revegetation

(3) Plant-soil-water relations

(4) Brush and weed management

(5) Plant induced animal disorders

(6) Rangeland insects, nematodes, and diseases

(7) Management systems

(8) Water management

(9) Plant-animal relationship

(10) Socio-economic

(11) Remote sensing

2. Brush Control Research, College Station, TX

Worksites: Bryan, Llano, Millican, Riesel, Temple, and Victoria, TX

a. Mission: Develop principles and methods of safe and economical control of weeds and brush on pastures and rangelands and investigate the physiology, biochemistry, anatomy, morphology, and life cycles of herbaceous and woody plants in response to herbicides and other weed control practices.

b. Land Resource Region and Area (Austin, 1972):

Southwestern Prairies Cotton and Forage Region (J)
Texas Claypan Area (87)

Land Use: Primarily improved pasture
Elevation: 200 to 500 feet
Soil: Udolls and Ochrepts

c. Climate (Average):

Precipitation: 34 to 42 inches, winter - spring
Temperature: 65 to 70° F
Frost-free period: 240 to 280 days

d. Ecoregion: Humid Temperate Prairie, Prairie Parkland

e. Ecosystem (Forest Service, 1972):

Oak-Hickory Forest

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Oak-Hickory Forest:

Carya cordiformis, bitternut hickory
Carya ovata, shagbark hickory
Quercus alba, white oak
Q. ruba, red oak
Q. velutina, black oak

Others:

Fraxinus americana, American ash
Ulmus americana, American elm

g. Objectives:

(1) Develop new and improved weed control methods for integrated weed control systems for mesquite, huisache, whitebrush, Macartney rose, live oak, post oak, winged elm, yaupon, and smutgrass.

(2) Correlate absorption and translocation patterns of

herbicides with morphological, physiological, environmental, and mode-of-action considerations of selected plant species.

(3) Develop long-term weed control techniques using minimal herbicide applications from controlled release formulations.

(5) Determine threshold levels of weed populations requiring control, and study ecological succession and productivity of desirable and undesirable plants following weed control practices.

h. Status:

(1) Several new soil applied herbicides are showing promise for brush control when applied to the soil surface or subsurface. Pelleted herbicides can be applied by aircraft for drift control and treatment of large areas.

(2) Several new foliar applied herbicides are being studied for physiological responses, mode-of-action, absorption, and translocation in herbaceous and woody plants. This information is necessary to determine how herbicides affect the plant and provides clues to modify and improve their activity.

(3) Controlled release formulation of herbicides are being investigated for their effectiveness under field conditions. Controlled release formulations may allow reduced rates or provide long-term weed control which ultimately will result in improved and safer weed control practices at reduced cost.

(4) Herbicide residues are being monitored in the environment. Methods to reduce herbicide concentrations in air, water, soil, and vegetation are being studied by such techniques as subsurface application, pelleted herbicides, and controlled release herbicides.

(5) Knowledge of the density and competitive potential of weeds related to when populations need to be controlled for economic return is being studied. The effect of herbicides on the ecological succession and productivity of desirable and undesdirable vegetation is also necessary to determine the usefulness and economic return of a weed control practice.

i. Plans:

New and commercially available herbicides and carriers,

adjuvants, and formulations to make herbicides more effective will be evaluated on laboratory, greenhouse, and field-grown weeds and brush. The most promising herbicides, herbicide mixtures, or herbicide formulations will be evaluated by field plot techniques using either ground or aerial applicators. Minimum herbicide levels and rates will be established for effective brush control. Studies will be repeated in different years, experiments, locations, and weed and brush species until reproducible and reliable results are obtained. Promising herbicides from field plot studies will then be subjected to detailed studies on residues in the environment and mode-of-action investigations on weed or crop plants. If special application equipment is required to apply a specific herbicide, it will be developed for proper placement of the material. The herbicide will also be evaluated for its effect on productivity of forage species as well as weeds. The acquired information will be necessary for registration, economical, and safe use of the herbicide in agricultural practices.

j. Opportunities and Needs:

Some of the major range research needs are:

(1) New and unconventional approaches to weed and brush control.

(2) The impact of weed and brush control on livestock production and wildlife habitat, water quality and quantity, and ranch economics.

(3) Ecology of weeds--their interrelationship with other weeds, forage plants, and wild and domestic animals.

(4) Integrated weed control systems including fire, mechanical, and biological methods.

(5) Improvement of herbicide efficiency with better herbicide formulations and application equipment

(6) Residues and fate of herbicides in ecosystems and specific weed species.

(7) Mode-of-action of herbicide and physiological response of plants to herbicides.

(8) Potential value of unwanted range plants for pharmaceutical, industrial, or energy sources.

Need increased SY's for a complete and adequate weed and brush control and management program. Additional personnel include a formulation chemist, biochemist, ecologist

and plant physiologist, and adequate support personnel. Support and support personnel are inadequate for an efficient field program.

Crop Genetics and Improvement Research, College Station, TX

Worksites: Beeville, Dallas, El Paso, Knox City, and Weslaco, TX

a. Mission: Develop new and improved genetic populations, breeding lines, and cultivars of forage crops that combine improved yield potentials and favored quality characters, including reduced content of undesirable constituents, with better resistance to pests, tolerance to environmental stress, conservation of scarce resources, and adaption of mechanized culture, harvesting, and handling.

b. Land Resource Region and Area (Austin, 1972):

Southwestern Prairies Cotton and Forage Region (J)
Texas Claypan Area (87)

Land Use: Primarily improved pasture
Elevation: 200 to 500 feet
Soil: Usterls, Udolls, and Ochrepts

c. Climate (Average):

Precipitation: 34 to 42 inches, winter - spring
Temperature: 65 to 70° F
Frost-free period: 240 to 280 days

d. Ecoregion: Humid Temperate Prairie, Prairie Parkland (College Station).

e. Ecosystem (Forest Service, 1972):

Oak-Hickory Forest

f. Potential Natural Vegetation and Major Plant Species Kuchler, 1964):

Oak-Hickory Forest

Carya cordiformis, bitternut hickory
Carya ovata, shagbark hickory
Quercus alba, white oak
Q. ruba, red oak
Q. velutina, black oak

Others:

Fraxinus americana, American ash
Ulmus americana, American elm

g. Objectives:

(1) Determine mode of reproduction, meiotic behavior, and ploidy levels in new forage grass accessions and breeding lines. Identify reproductive and cytological abnormalities, establish relationships, and select potentially useful germplasm.

(2) Investigate the basic nature and inheritance of apomicitic mechanisms, and determine the potential for intra- and inter-specific manipulation of apomixis as a means for rapid transfer and permanent fixation of genes for important traits.

(3) Develop, evaluate, and release superior high quality forage grass cultivars.

(4) Determine forage quality of breeding materials, and assess the effectiveness of *in vitro* digestibility evaluation as an early selection index in breeding forage grasses.

h. Status:

(1) Many of the important warm-season perennial range grasses reproduce by apomixis. Knowledge of the apomictic mechanism is required to plan and develop effective improvement programs with these species. Control and manipulation of mode of reproduction have been achieved in buffelgrass, and obligate apomixis is being used as a breeding tool to produce true breeding apomictic F_1 hybrids. Two new apomictic hybrids, "Nueces" and "Llano," were released in late 1977. Much remains to be learned about the casual aspects of apomixis, interspecific transfer of genes controlling mode of reproduction, and use of apomixis in other species.

(2) Basic cytology and cytotaxonomic relationships are important in planning intra- and interspecific breeding programs. Many of the forage grasses are polyploid, and little is known of the genetics of important agronomic traits. This information is required on numerous species and accessions.

(3) Development of cold tolerance, better performance under stress, and improved forage quality are primary objectives in the arid Southwest. Considerable effort is being devoted to identification of cold resistant germplasm in *Cenchrus* and *Pennisetum*. Some 800 accessions of buffelgrass collected in South Africa in 1976 are being evaluated as time permits. Considerable progress has been made in identifying

promising germplasm. Much remains to be done in the areas of basic cytology, mode of reproduction, and range of adaptation of this material.

i. Plans:

The future research plan will involve efforts to combine tissue tolerance to freezing with strong rhizome development. Tissue tolerance to freezing will come from collections made at high altitudes in South Africa. Germ plasm in the breeding program has strong rhizomes which tend to provide some winter protection along with drought tolerance, forage productivity, and quality.

j. Opportunities and Needs:

Evaluation of a vast array of new accessions and new germplasm under a wide range of environments requires considerably more subprofessional support and financial resources than presently available. Experience in Africa showed that buffelgrass strains are often site-specific, indicating a need for widespread field testing of new accessions.

3. Southern Plains Watershed and Water Quality Laboratory, Durant Chickasha, OK:

a. Mission: Develop information needed to protect and manage the quality of the nation's water resources arising from agricultural and nonurban lands; evaluate the quality and quantity of water from agricultural watersheds as practices and management systems evolve to meet increasing demands for food, water, and energy.

b. Land Resource Region and Area (Austin, 1972):

South Atlantic and Gulf Slope Cash Crop, Forest and Livestock Region (P)
Southern Coastal Plain (133)
Southwestern Prairies Cotton and Forage Region (J)
Cross Timbers (84)
East and Central General Farming and Forest Region (N)
Ouachita Mountains (119)

Land Use: 20 to 50% rangeland
25% open woodland (grazed)
20 to 80% forested (grazed)

Elevation: 300 to 2,700 feet
Soils: Udults and Ochrepts

c. Climate (Average):

Precipitation: 25 to 40 inches, spring type
Temperature: 55 to 65° F
Frost-free period: 200 to 250 days

d. Ecoregion: Humid Temperate Prairie, Prairie Parkland

e. Ecosystems:

Post oak-blackjack forest
Oak-pine forest

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Andropogon gerardi, big bluestem
Panicum virgatum, switchgrass
Schizachyrium scoparium, little bluestem
Sorghastrum nutans, Indiangrass
Quercus marilandica, blackjack oak
Q. stellata, post oak

g. Objectives:

(1) Development of mathematical models to describe and predict runoff and the movement of nutrients and other related chemicals from agricultural watersheds.

(2) Relate changes in range condition and species under different management practices to changes in the amount and distribution of soil water; relate the above changes to changes in the amount and quality of storm runoff.

(3) Development of management practices for vegetation ecosystems associated with farm ponds.

h. Status:

(1) Participating in the USDA-SEA land runoff modeling effort with special emphasis on nutrient and sediment transport relations.

(2) Sparse vegetative cover, as from overgrazing, is known to increase amounts of runoff and erosion. Information is needed on the effects of range improvement practices on the quantities of runoff, infiltration, deep percolation, and evapotranspiration of water. Changing land use from grazing to wheat cropping, or vice versa, probably affects water quality. Information on these effects is needed for watershed planning for improved water quality and in connection with the Rural Clean Water Act.

(3) Plant competition experiments are being conducted in small plots and model ponds. Potential field sites have been identified.

i. Plans:

Grassland watersheds have been established at El Reno and Woodward, Oklahoma, and Bushland and Riesel, Texas. Hydrology, erosion losses, and quality of runoff water will be determined. At El Reno, different intensities of grazing, burning, herbicides, and fertilizer applications will be used in grassland management. Data will be taken on percent ground cover, species composition, total live and dead weight of cover, root weight, and soil moisture distribution in three depths. Water quality measurements include concentrations of plant nutrients, herbicides, and bacteria. Multivariate analysis will be used to associate water use or runoff water quality with major species classes. To the extent possible, similar treatments and observations will be made at the other three locations.

j. Opportunities and Needs:

National water quality goals for fishable and swimable streams and small lakes have been established by legislation. Research at this location is basic to development of criteria and methodology to manage land and water resources to meet these national goals.

The effects of vegetation manipulation on quality and quantity of runoff water from rangeland watersheds including type of cover, grazing intensity, duration and degrees of grazing use, grazing systems, burning, range tillage, and use of pesticides and fertilizers need to be determined. Mathematical models need to be developed to incorporate effects of vegetation management upon ground water recharge, streamflow, soil erosion, sedimentation, and water quality.

4. Southwestern Livestock and Forage Research Station, El Reno, OK

Worksites: Stillwater, OK

a. Mission: Develop forage crops systems utilizing improved pastures and legumes for pasture/hay production to provide year-round forages of high quality for livestock production. Investigate biological/biochemical interactions between grass and legume species affecting nitrogen-fixation potentials of legumes, availability of symbiotically fixed nitrogen for the companion plant species, effect on soil nutrients, pH, and lime requirements.

b. Land Resource Region and Area (Austin, 1972):

Central Great Plains Winter Wheat and Range Region (H)
Central Rolling Red Prairies (80)

Land Use: Farmer-stocker operations
Elevation: 1,000 to 1,500 feet
Soil: Ustolls, Ustalfs, and Ochrepts

c. Climate (Average):

Precipitation: 23 to 35 inches, spring, summer
Temperature: 57 to 65° F
Frost-free period: 190 to 240 days

d. Ecoregion: Humid Temperate Prairie, Tall-grass Prairie

e. Ecosystem (Forest Service, 1972):

Plains grasslands

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Bluestem-Grama Prairie

Bouteloua curtipendula, side-oats grama
B. gracilis, blue grama
Schizachyrium scoparius, little bluestem

Others:

Agropyron smithii, western wheatgrass
Andropogon gerardi, big bluestem
Buchloe dactyloides, buffalograss
Panicum virgatum, switchgrass
Sorghastrum nutans, Indiangrass
Sporobolus asper, tall dropseed

g. Objectives:

(1) Determine nitrogen-fixing potential of legumes and the availability of symbiotically-fixed nitrogen to companion plants.

(2) Study the relationships between leaf photosynthesis and yield (dry matter production), and between leaf photosynthesis and N-fixation in legumes under various stress conditions.

(3) Evaluate the potential of improved varieties and cultivars of legumes for their compatibility with grasses under different management strategies and environmental stresses.

h. Status:

(1) Legumes have not been studied extensively in this area, and there is a definite need to develop a good breeding program to study potential sources of germ plasm for efficient nitrogen-fixation capability and compatibility of these legumes in mixture with improved grasses.

(2) There are a number of important physiological and ecological questions that need to be explored when legumes are included with fall, winter, or summer forage programs. These include, the evaluation of nitrogen-fixation potentials of legumes, the influence of companion crop on nodulation and rhizobium association with legumes, the impact of grazing pressure on the mixtures, and the overall economic aspects of grass-legume forage production.

i. Plans:

(1) To evaluate the potentials of grass and legume species and their varieties under different cultural, management, and utilization practices in a given environment as a quality forage for livestock production.

(2) To investigate the production potentials of native grasslands by manipulating the range conditions through fertilization, irrigation, and overseeding with native or introduced exotic legume species.

(3) To develop methods to study and understand the ecology of grass-legume ecosystems such as nitrogen-fixation, nutrient cycling, and energy flow dynamics.

j. Opportunities and Needs:

To understand the ecophysiology of grass legume systems, we need to have an interdisciplinary research group representing different discipline areas such as soil science, disease and weed control, breeding, chemistry, etc. Research needs include the accumulation and evaluation of potential sources of grass and legume species, varieties, cultivars/lines and germ plasm, and the development of a comprehensive grazing program with legumes as a prominent and essential component of any forage production program.

5. Forage Seed Technology Research, Stillwater, OK

Worksites: El Reno and Woodward, OK

a. Mission: Develop cultural and management practices and

harvesting methods on new and improved grasses, both native and introduced, that reduce production losses, increase seed yield, and improve seed quality and preservation.

b. Land Resource Region and Area (Austin, 1972):

Central Great Plains Winter Wheat Region (H)
Central Rolling Red Prairie (80)
Southwest Prairie and Cotton Forage Region (J)
Cross Timbers (84)

Land Use: 50% ranches and grazable woodland
50% small farms and woodland

Elevation: 1,000 to 2,000 feet
Soils: Ustolls, Ustalfs, and Ochrepts

c. Climate (Average):

Precipitation: 25 to 30 inches, spring, summer
Temperature: 57 to 65° F
Frost-free period: 185 to 240 days

d. Ecoregion: Humid Temperate Prairie, Prairie Parkland

e. Ecosystems (Forest Service, 1972):

Plains grassland
Crosstimbers

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Andropogon gerardi, big bluestem
Panicum virgatum, switchgrass
Schizachyrium scoparius, little bluestem
Sorgastrum nutans, Indiangrass
Quercus marilandica, blackjack oak
Q. stellata, post oak

g. Objectives:

(1) Evaluate the potential of new and improved Old World bluestem strains developed in breeding programs for seed production in the Southern Plains.

(2) Determine cultural and management practices under both irrigated and dryland conditions that increase seed production of improved native and introduced grasses as evidenced by seed stalk production, seed-set, and seed weight.

(3) Evaluate equipment and develop new, more efficient harvesting techniques for chaffy seeded grasses.

(4) Investigate the physiological requirements for maximum germination and seedling growth of grass and legume seed.

h. Status and Plans:

(1) Studies on cultural and management practices that maximize Old World bluestem(s) seed production are incomplete. Seed production systems have been developed and used successfully by grower(s) of "Plains" bluestem. Several other Old World bluestem strains are being evaluated. Results of this work has played a major role in the successful release and continued production of seed by growers of several improved grasses as well as introduced.

(2) Pilot studies are in progress on selected Big Bluestem and gammagrass accessions in regard to forage production, forage quality, seed-stalk production, racemes/stalk, and seed-set/raceme under irrigated conditions. Factors limiting seed-set are being assessed.

(3) A proto-type model of a grass seed stripper developed by Oklahoma Agricultural Engineering Department, OSU, for harvesting chaffy seed grasses is being evaluated on growers' production fields across the state. Preliminary findings suggest the harvesting efficiency is superior to other methods of harvesting chaffy-seeded grasses. Modifying the harvester to harvest other kinds of grass seeds is planned. Associated equipment, e.g., on the farm dryers, for processing and handling grass seed will be evaluated.

(4) Quality, size, germination, and vigor of seed is known to be influenced by conditions under which the seed ripens. We know very little about this except by observation that some seasons produce better seed than others. Conditions in the Southern Great Plains that produced reasonably high yields of well-filled seeds usually cause a high degree of dormancy as well. The physiological requirements for maximum germination and optimum growth of seedling, location and nature of seed dormancy, and stand establishment are areas of concern.

i. Opportunities and Needs:

Need increased SY's, especially in the areas of weed science and entomology (grass-seed and forage feeding

insects), and technical support to work with existing forage seed technology group. Greenhouse, seed, and equipment storage facilities are grossly inadequate.

6. Grassland-Forage Research Center, Temple, TX

Worksites: Alpine, Beeville, Big Spring, Brady, Crystal City, Eldorado, Kingsville, Laredo, Ozona, Raymondville, Stephenville, and Uvalde, TX

a. Mission: Develop new and improved forage crops that combine ease of establishment, productivity, forage quality, persistence, and tolerance to stress; develop chemical and biological control of unwanted range plants; follow degradation of herbicides in soil, plant, and water systems; develop improved management practices for range forage production including plant nutrition, water conservation, and machinery, and assess effects of management practices on runoff water yields and sediment from range watersheds.

b. Land Resource Region and Area (Austin, 1972):

Southwestern Prairies Cotton and Forage Region (J)
Texas Blackland Prairie (86)

Land Use: 20% in improved pasture
Elevation: 300 to 800 feet
Soil: Vertisols, Ustalfs, Ustolls, and Ochrepts

c. Climate (Average):

Precipitation: 30 to 50 inches, spring
Temperature: 63 to 70° F
Frost-free period: 230 to 280 days

d. Ecoregion: Humid Temperate Prairie, Prairie Brushland

e. Ecosystem (Forest Service, 1972):

Prairie

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Blackland prairie

Major potential species:

Schizachyrium scoparius, little bluestem
Stipa leucotricha, Texas needlegrass

Others:

> <u>Andropogon gerardi</u>, big bluestem
> <u>A. saccharoides</u>, silver bluestem
> <u>Aristida purpurea</u>, purple three-awn
> <u>Bouteloua curtipendula</u>, side-oats grama
> <u>B. hirsuta</u>, hairy grama
> <u>B. rigidiseta</u>, Texas grama
> <u>Buchloe dactyloides</u>, buffalograss
> <u>Panicum virgatum</u>, switchgrass
> <u>Sorghastrum nutans</u>, Indiangrass
> <u>Sporobolus asper</u>, tall dropseed

g. <u>Objectives</u>:

(1) Determine effective breeding procedures for apomictic <u>Eragrostis</u> sp., and develop improved varieties.

(2) Evaluate extent of variability in leaf wax content, seedling root growth, and seedling drought tolerance in forage grasses, the heritabilities of these characteristics, and their interrelationships.

(3) Evaluate the germplasm resources of Kleingrass and related <u>Panicum</u> species, and develop improved Kleingrass varieties.

(4) Evaluate harmful and beneficial values of weeds; determine the biology and effect of key organisms that attack weeds in the U.S.; find and test promising organisms that attack weeds overseas; introduce promising organisms into the U.S.; evaluate amount of control obtained and integrate with other control methods.

(5) Determine the rate of herbicide movement, accumulation, and degradation as related to time of application and rainfall amounts and intensity. Determine efficacy of new herbicides on herbaceous range weed and brush species.

(6) Develop improved equipment and techniques for tilling, planting, transplanting, fertilizing, and cultivating to increase production, reduce labor and machinery costs, and reduce use of fossil fuel.

(7) Develop water management systems and principles to increase production of both rangeland and tame pastures.

(8) Evaluate the more drought tolerant <u>Paspalum</u> species for forage production and adaptation.

h. Status:

(1) Knowledge of the inheritance of apomixis in weeping lovegrass is incomplete, but potential breeding schemes have been developed. Hybrids are being produced. Synthetics of blue grama and sand bluestem are being evaluated.

(2) Initial characterization of selected forages in regard to leaf wax, seedling root growth, and drought tolerance have been performed, and their heritabilities and interrelationships are now being studied.

(3) Collections of Kleingrass and related species are being established at several locations. Characteristics of specific interest include: establishment characteristics, development of seedling vigor, seed production, persistence, pest resistance, quality, quantity, and adaptation.

(4) Surveys for natural enemies of weeds were conducted in North and South America, and preliminary research on biology of most important insect species have been initiated.

(5) Promising herbicides for control of brush and weeds are being studied for their efficacy and persistence in the environment.

(6) Methods for maintaining adequate soil water around germinating seeds or quickly establishing plants during short periods when soil water is adequate are being developed. An automatic transplanting system is being developed for establishment of forage species. Plant nutrient requirements critical to establishment, maintenance, and production of forage grasses are being assessed.

(7) A large collelction of Paspalum introductions from South America is assembled at Temple, and some of the species with drought tolerance are being increased for forage evaluation tests.

i. Plans:

Evaluate lovegrass hybrids for improved forage quality, winter survival ability, iron efficiency, and drought resistance. Identify superior characteristics of Kleingrass as well as the causal agent of "swellhead" or photosensitization of lambs grazing Kleingrass. Evaluate Paspalum species under different environments. Continue biological and chemical control of weeds and brush. Methods of seedling establishment will be evaluated. Computer

studies of runoff will be initiated. Establish new program on the physiology and biochemistry of herbicide efficiency in brush and weeds.

j. Opportunities and Needs:

Some of the major research needs are:

(1) Breeding plants for increased resistance to stress and for quality and quantity of forage.

(2) Revegetation studies for seedling establishment, methods, and adaptability to grazing.

(3) Ecology, damage, and control of unwanted plants, nematodes, and insects.

(4) Control of competitive brush and toxic weeds by biological control, chemical control, burning, and range management.

(5) Develop complementary pastures.

(6) Develop grazing system for native range plus complementary pastures.

(7) Study effects of manipulative treatments on water quality and quantity, erosion and sedimentation, moisture conservation, and animal performance and behavior.

(8) Basic research on the physiology of native and introduced forage species of brush and weeds on water use by plants and plant-animal interactions.

(9) Modeling the range system.

7. Soil and Water Conservation Research, Weslaco, TX

Worksites: Rio Grande City and Zapata, TX

a. Mission: Improve forage production and wildlife habitat; increase utilization of native species; introduce new species; and apply remote sensing techniques to improve range management.

b. Land Resource Region and Area (Austin, 1972):

Southwestern Plateaus and Plains Range and Cotton Region (I)
Rio Grande Plains (83)

Lane Use: 80% in ranching
Elevation: Sea level to 1,000 feet
Soil: Ustolls, Ustalfs, and Vertisols

c. Climate (Average):

Precipitation: 20 to 30 inches, spring, fall
Temperature: 70° F
Frost-free period: 260 to 320 days

d. Ecoregion: Humid Temperate Prairie, Prairie Brushland

e. Ecosystem (Forest Service, 1972):

Texas Savanna

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Mesquite-Acacia Savanna

Acacia rigidula, blackbrush acacia
Andropogon littoralis, seacoast bluestem
Prosopis juliflora var. glandulosa, mesquite
Setaria macrostachya, plains bristle grass

Others:

Andropogon saccharoides, cane bluestem
Aristida spp., threeawns
Cenchrus myosuroides, grass burr
Heteropogon contortus, tanglehead
Optunia spp., prickly-pear cactus

g. Objectives:

Increase yields from rangeland through more efficient use of precipitation, and improve management of rangelands for maximum livestock and wildlife production.

h. Status:

Rootplowing of brushland and seeding to buffelgrass increased forage production 3- to 4-fold. Prickly-pear cactus was utilized by cattle, whitetailed deer, and javalina.

i. Plans:

Evaluate rate of brush manipulation, revegetation of sand and saline sites; study establishment of warm- and cool-season legumes and other browse species; evaluate plant

nutrition; study diets of range animals; measure germination responses of shrubs and grasses, and investigate the use of small scale color-infrared photography for the inventory and classification of South Texas rangelands.

j. Opportunities and Needs:

With increased personnel, fourwing saltbush, buffelgrass, coastal Bermudagrass, weeping lovegrass, legume spp., cenizo, cactus, and guajillo could be improved. Buffelgrass, winter grains for forage, Bermudagrasses, Rhodesgrass, plains bristlegrass, Old World bluestems, Angleton bluestem, and Kleberg bluestem should be evaluated for revegetation purposes.

8. Southern Plains Range Research Station, Woodward, OK

Worksites: Bartlesville, Fort Supply, and Goodwell, OK; Coldwater, Iuka, Manhattan, and Salina, KS; Dalhart Knox City and Temple, TX; Scottsbluff, NE; Dixon Springs, IL.

a. Mission: The mission of the Southern Plains Range Research Station is to increase the efficiency of red meat production and range resource utilization through integrated management of energy flow, nutrient cycling, and hydrologic dynamics in forage-animal production systems in a manner consistent with perpetuation of the range resource. Advancement toward this goal will come through increased understanding of the structure and function of the complex range ecosystem and the application of new principles to the management of the soil-plant-animal system.

b. Land Resource Region and Area (Austin, 1972):

Central Great Plains Winter Wheat and Range Region (H)
Central Rolling Red Plains (78)

Land Use: 50-90% in ranches
Elevation: 1,500 to 3,000 feet
Soil: Aridosol, Ustolls, Ocherepts, and Psamments

c. Climate (Average):

Precipitation: 20 to 30 inches, spring, fall
Temperature: 57 to 65° F
Frost-free period: 185 to 230 days

d. Ecoregion: Dry Steppe, Great Plains Shortgrass Prairie

e. Ecosystem (Forest Service, 1972):

Plains grasslands

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sandsage-bluestem prairie

Andropogon hallii, sand bluestem
Artemisia filifolia, sandsage
Bouteloua gracilis, blue grama
Schizachyrium scoparius, little bluestem

Others:

Bouteloua hirsuta, hairy grama
Buchloe dactyloides, buffalograss
Calamovilfa longifolia, prairie sandreed
Eragrostis trichodes, sand lovegrass
Helianthus petiolaris, prairie sunflower
Panicum virgatum, switchgrass
Sporobolus cryptandrus, sand dropseed
Stipa comata, needle-and-thread
Yucca glauca, small soapweed

g. Objectives:

(1) Determine superior genotypes of Old World bluestems and eastern gamagrass; determine their response to management treatments; combine better traits of eastern gamagrass into superior varieties through selection and hybridization.

(2) Increase available soil nitrogen through the use of native and introduced range legumes and other biological sources in greenhouse, plot, and field studies and by the use of commercial fertilizers and inhibition of denitrification biologically and chemically; improve soil-water relationships by reducing evapotranspiration through tillage, mulch, tall plants, and chemical retardants.

(3) Determine the photosynthetic response and carbohydrate uptake and storage dynamics to grazing management strategies, drought, above- and below-ground insects, and diseases for the important rangeland species in the Southern Plains; develop grazing management systems that provide sustained yields of nutritional forage commensurate with soil and water conservation.

(4) Develop stocker and cow-calf management programs that utilize natural and managed ecosystems to increase efficiency of red meat production in the Southern Plains.

h. <u>Status</u>:

(1) Several hundred accessions of Old World bluestems and eastern gamagrass are being evaluated. Studies on eastern gamagrass on morphological development, dates and densities of planting, yield potential, and effects of cultural and utilization management treatments are in progress.

(2) The soils research at the Southern Great Plains Range Research Station is designed to (1) provide fertility and soil moisture information needed in developing, establishment, and maintenance of grazing management systems, (2) provide soils input into basic variety improvement and plant physiological ecology research, and (3) monitor long-term trends in fertility and soil physical conditions as affected by current and experimental range management practices.

(3) A plant physiologist, a soil scientist, and a chemist have been recruited.

(4) Groundwork has been developed for evaluating stocker and cow-calf management systems. New work will soon begin on evaluating the beef-cow type-environment interaction between two types of cattle and native range and native range-complementary forage regimes.

i. <u>Plans</u>:

Develop an understanding of the structure, function, and utilization of range and associated ecosystems. Develop more information of nutrient cycling and water relations of various range sites. Study use of improved forages to increase the potential of range and related agronomic ecosystems. Study plant-livestock interactions including management of complementary systems, nutrient transfer, energy flow, and range system modeling.

j. <u>Opportunities and Needs</u>:

The major range research needs are:

(1) Determine potential of range sites.

(2) Species relationships, evaluate adaptability and breeding for resistance to stress, photosynthetic efficiency, and nitrogen fixation.

(3) Diet, nutrition, and performance of livestock in relation to environments (management strategies).

(4) Basic research in plant-environment interactions, water use by plants, plant-animal interactions, and nitrogen fixation.

(5) Modeling the range system.

Need to add additional scientists in the areas of range science, animal science, physiological and community ecology, soil science, and forage agronomy. All scientists must be supported by highly qualified research associates and technicians, adequate equipment, and well equipped laboratory space.

B. Research Teams:

Eight research teams have been identified (Table 1) based on the research needs discussed in Section III A. The scientific composition of the teams was developed at the Range Research Planning meeting in Las Cruces, New Mexico (November 1978), and reviewed by Research Leaders at the various locations in the OTA. Appendix I details the assignment of various scientists to specific teams based on their NRP relationships (Appendix F) and primary research categories (Appendix H). Table 2 shows the present staffing of the research teams. Recommendations are discussed further in Section VI.

1. Forage improvement:

Current forage improvement work by agronomists and plant geneticists is centered primarily at Temple and College Station (6.74 SY's). The forage improvement team should also include a range scientist as well as an animal nutritionist.

2. Management systems:

Four locations (Woodward, College Station, Temple, and El Reno) are involved, to varying extents, in range management systems research. The current 3.12 SY's are spread thinly among a range scientist, agronomist, plant physiologist, soil scientist, and agricultural engineer. Additional expertise is needed in plant ecology and range biology to properly investigate the impact of management systems on the diverse range ecosystems.

3. Revegetation:

Temple is the primary location for revegetation investigations with 0.46 SY spread among a soil scientist, plant geneticist, and plant physiologist, and 1.0 SY in an agricultural engineer. This research team should also include expertise in range science and agronomy.

4. Brush and weed management:

   Approximately eight kinds of scientists are needed for brush and weed management research. These include a plant physiologist, agronomist, agricultural engineer, entomologist, range scientist, plant pathologist, ecologist, and chemist. Currently, 6.58 SY's are devoted to brush and weed management research, primarily at College Station and Temple. The disciplines currently represented include plant physiology, agronomy, agricultural engineering, and entomology.

5. Water management:

   Water management research is located primarily at Durant-Chickasha and Temple. Currently, scientists (4.65 SY's) involved include a soil scientist, agronomist, agricultural engineer, hydrologic engineer, geologist, and micro-biologist. To complete the water management research team for range ecosystems, a range scientist should be added to this team.

6. Soil-plant-water relations:

   This research consists of 2.70 SY's located at Bushland, Temple, and Woodward. This team, to be properly staffed, should also include expertise in agronomy, range science, and plant physiology. It is possible that these latter expertise could be obtained by cooperative work with scientists among other research teams.

7. Plant-animal relations:

   This research is conducted primarily at the Woodward and El Reno locations. This team currently consists of 0.5 SY spread thinly between a range scientist and an animal scientist.

8. Remote sensing:

   This research, located primarily at Weslaco, TX involves a range conservationist, a soil scientist, and an agricultural engineer (2.2 SY's).

Table 2. Research teams needed to meet research needs in the Southern Plains Region (see Appendix I for assignment of various OTA scientists to the respective teams).

Research team, location and types of scientists needed	Present SEA	Present Coop	Not present	Potential for adding to team: Hire	Transfer	Cooperative other SEA units	Cooperators Univ.	Cooperators State	Cooperators Fed.	Comments
1. FORAGE IMPROVEMENT										
Temple, Woodward, College Station, Stillwater, and El Reno										
1. Agronomists	2.00		1.00	1.00						
2. Plant geneticists	4.74									
3. Range scientists			1.00	1.00						
4. Animal nutritionists			1.00		1.00					
2. MANAGEMENT SYSTEMS										
Woodward, College Station, Temple, and El Reno										
1. Range scientists	0.80		1.00	1.00[1/]						
2. Agronomists	0.60		1.00	1.00						
3. Plant physiologists	1.20									
4. Synecologist (plant community ecologist)			1.00							
5. Soil scientist	0.40									
6. Agricultural engineers	0.12		1.00							
7. Biologists			1.00							
3. REVEGETATION										
Temple										
1. Soil scientists	0.20		1.00							
2. Plant geneticists	0.20									
3. Plant physiologists	0.60									
4. Agricultural engineers	1.00		1.00		1.00					
5. Range scientist			1.00							
6. Agronomists			1.00							
4. BRUSH AND WEED MANAGEMENT										
College Station and Temple										
1. Plant physiologists	2.80									
2. Agronomists	1.70									Cooperative work with SAES could provide some assistance.
3. Agricultural engineers	1.08		2.00	1.00	1.00					
4. Entomologists	1.00		2.00	1.00	1.00					
5. Range scientists		2.00	2.00	2.00						
6. Plant pathologists			1.00		1.00					
7. Ecologists			2.00	2.00						
8. Chemists			2.00		2.00					

Table 2. (Continued)

Research team, location and types of scientists needed	Present SEA - Coop	Not present	Potential for adding to team: Hire	Transfer	Cooperative other SEA units	Cooperators: Univ.	State	Fed.	Comments
5. WATER MANAGEMENT									
Durant-Chickasha and Temple									
1. Soil scientists	1.20								
2. Agronomists	0.20								
3. Agricultural engineers	1.20								
4. Hydraulic engineers	1.65								
5. Geologists	0.10								
6. Microbiologists	0.30								
7. Range scientists	4.65	1.00							
6. SOIL-PLANT-WATER RELATIONS									
Temple, Woodward, and Bushland									
1. Soil scientists	1.70								
2. Agricultural engineers	1.00								
3. Agronomists		1.00			1.00				
4. Range scientists		1.00			1.00				
5. Plant physiologists		1.00			1.00				
7. PLANT-ANIMAL RELATIONS									
Woodward and El Reno									
1. Range scientists	0.20								
2. Animal scientists	0.30	1.00	1.00						
3. Agronomists		1.00			1.00				
8. REMOTE SENSING									
Weslaco									
1. Range scientists	1.00								
2. Soil scientists	1.00								
3. Agricultural engineers	0.20								
4. Agronomists		1.00			1.00				

1/ Funded.

V. Research Gaps

A. Research Teams:

1. Forage improvement:

Much remains to be learned about the casual aspects of apomixis, interspecific transfer of genes controlling mode of reproduction, and use of apomixis in other species. Basic cytology and cytotaxonomic relationships are important in planning intra- and interspecific breeding programs. Many of the forage grasses are polyploid, and little is known of the genetics of important agronomic traits. Much remains to be done in the areas of basic cytology, mode of reproduction, and range of adaptation of forage grasses.

There is little effort in the tissue culture of range species. For many years, progress in tissue culture has been slow. Recently, progress has speeded up. It appears that rapid advancement towards solving regeneration problems can now be made, and that the time when tissue culture will be a valuable tool to the plant breeder is rapidly approaching.

Evaluation of a vast array of new accessions and new germplasm under a wide range of environments requires considerably more subprofessional support and financial resources than presently available. Experience in Africa showed that buffelgrass strains, for example, are often site-specific, indicating a need for widespread field testing of new accessions. This is true of most new plant materials because of the wide variation in range sites and climatic environments.

New efforts need to be established on forbs and browse, especially in the Southern Great Plains. Forb work (including legumes) could be carried out at a location such as Woodward, Oklahoma. Browse work might be located at San Angelo or Uvalde, Texas. Initial efforts in both programs should be directed towards determining the species with greatest potential. Improvement work should follow on the selected species. Disciplines required include agronomy, range science, genetics, microbiology, and animal nutrition.

Programs are operational in the area of forage evaluations, but additional support is needed for animal nutrition and agronomic/range science evaluations. This will provide additional input in the forage quality and resistance of plants to abusive management and will allow the geneticists more time to work more closely with physiologists and soil scientists in the areas of establishment, drought resistance, winter-survival ability, and adaptation to specific soil conditions.

2. Management systems:

Range ecosystem management strategies need to be developed that are based on a knowledge of the morphological and physiological characteristics of the plant and macro- and micro-climatic interrelationships. The impact of these strategies on other resource users, i.e., watershed management, recreation, and wildlife management, must be concurrently studied.

Integrated research on range and complementary forage systems utilizing the holistic approach requires on-site coordinated studies involving range science, animal science, agronomy, plant physiology, plant ecology, soil science, biology, and agricultural engineering.

3. Revegetation:

The Texas Association of Soil and Water Conservation Districts, in their 1976 Report of Conservation Problems, listed "difficulty of grass establishment" as their No. 2 need for research. Basic research on the problems of establishing range and forage plants is needed. The research should include plant nutrition, machinery development, and engineering aspects of water conservation and control. In addition, research on the water and temperature requirements of many different kinds of grass and forage plants are needed.

There is not much effort being expended directly on plant nutrition research in the area of range revegetation in the Southern Great Plains. Much work seems to be carried on as corollary to other main thrusts as, for example, use of fertilizers in range management studies or forage production and quality studies. A number of reasons may exist for this, among which are: a feeling that sufficient transferable technology or information already exists with respect to plant nutrition of other agricultural crops, the overwhelming importance of inadequate water for nutrient response under semiarid grassland conditions, expectation of more direct benefits at less expense from researching management practices such as brush control and grazing systems, and negative results about the economy of fertilizer costs on rangeland.

One of the major problems encountered in semiarid climates is grass stand establishment, and a major part of that problem certainly does stem from unavailability of water. However, the ability of the grass plant to perform when water becomes available, and to withstand subsequent periods of drought, just as certainly involves its mineral nutrient status during initial seeling stages and throughout the life of the stand. Semiarid perennial grassland agriculture is sufficiently unique that information gathered from row crops and pastures under humid or irrigated conditions does not easily transfer without a more complete understanding of the rangeland ecosystem.

Much progress could be made towards increasing livestock forage production on selected rangeland sites by improving the probability of grass stand establishment through a concerted team effort of which specific studies of grass mineral nutrition would be a significant part. Such effort would involve cooperation between scientists from several related disciplines including range science, soil science, plant breeding, plant physiology, agronomy, water management, and agricultural engineering.

4. Brush and weed management:

Biochemical and physiological research is needed to study the fate of herbicides within both noxious and desirable range species following root uptake. Translocation and the various means of detoxification should be investigated.

Important contributions can be made concerning the identification and evaluation of formulations (both molecular and carrier) for pelleted herbicides which will aid in overcoming the major weaknesses of those currently available. These weaknesses include strong absorption of the herbicide to clays and organic matter and reduced activity if rainfall does not occur soon after distribution. Other related aspects are also important, such as the slow release formulations. Proprietary considerations should not hinder this research.

In view of the continuing trend toward use of soil applied herbicides and the advantages over conventional sprays, development of acceptable ground and aerial equipment for uniform and accurate distribution of these materials should be stressed.

5. Water management:

Future research on water management for plant production should include integrated studies by range, soil, water, and animal scientists in the overall optimal design of water management systems. This interdisciplinary group should consider the general problem of augmenting natural precipitation through water management. These studies would include water harvesting, water spreading from epehemeral streams, bench terraces, micro-watersheds, or water runoff from highway variables. Plant growth and water use are part of a complex, interrelated system affected by solar energy, precipitation, soil, and other factors. It is important that models describing the interrelations of each element of the system be developed in a forage research program. Such a model will help identify areas where knowledge is limited and additional research is needed.

Water harvesting with associated water spreading needs to be tested for its economic potentials of increasing the animal carrying capacity of rangelands. Future research in rangelands must also consider the interrelationships of water and nutrient requirements and how they can be managed to increase and improve

forage production.

Watershed models, including components for the hydrologic cycle, erosion and sediment yield, and agricultural chemicals, need to be developed so that they can be used as an operating tool.

Because it is impossible to measure the multitude of variables involved in the widely varying physiographic, climatic, and cultural conditions encountered in the western ranges, models will probably be the means for optimizing rangeland management schemes.

In the future, model components must be tested extensively and refined as necessary. This is particularly true of the nutrient models. One of the most urgent needs is the addition of a submodel for simulating grazing animals, which represent a set of complex processes. Consequently, range and pasture modeling to be much more difficult than cropland modeling. Data from range and pastureland basins will be essential in testing and validating the models.

6. Plant-soil-water relations:

   The efficiency of soil water use in the semi-arid Southern Plains is of major importance for enhanced productivity of range ecosystems. Nutrient cycling studies should be conducted on native and improved range plants to determine proper amount and timing of inputs. Further work is needed on nitrogen fixing plants for native range ecosystems and for incorporation in mixtures of improved perennial grasses and forbs.

7. Plant-animal relations:

   Much remains to be learned about the relationship between the nutritional quality and intake of native range forage species, improved plant materials, including forbs, legumes, and shrubs, as well as grasses and annual forage crops for both domestic animals and wildlife performance. These data will serve as base information in the development of range management systems. Evaluation of improved plant materials should emphasize red meat producing values as well as criteria related to conservation of water and soil resources.

   Grazing systems on native range and improved pastures need to be further evaluated as they relate to livestock responses. Another primary consideration to be studied should be the relationship between animal potential (genetics) and the range environment. Additional support at the Woodward location for an animal scientist is needed to provide such research capability.

8. Remote sensing:

The use of remote sensing techniques as a tool in range ecosystem inventory and analysis has not been realized. Such techniques need to be evaluated to determine their usefullness for identifying plant communities, detecting species composition, and determining range condition and trend. The utility of using imagery data to determine rangeland productivity needs to be tested in conjunction with quantification of range condition and its relationship to stresses such as drought and grazing.

VI. Recommendations

Table 2 lists the research teams by major research category and shows present and proposed needs in staffing according to current missions and implementation statements.

A. Specific Areas of Research:

The following specific research gaps are identified as being the most critical needs to be addressed.

1. A major research gap in the Southern Plains is integrated multi-disciplinary investigations on rangeland and related agronomic resource management systems. Efforts should be made to provide these research capabilities supported by scientists in range science, agronomy, plant physiology, plant ecology, soil science, biology, and modeling.

2. A concentrated effort is needed on the development of adapted leguminous plants for the semi-arid Southern Plains.

3. Plant breeding research is needed to develop improved plant material that meets criteria of integrated resource management strategies.

4. Research effort on the development of a heat tolerant cool-season species for the Southern Plains.

5. Development of vegetation schemes to improve the frequency and degree of success of stand establishment on various sites with varying potential based on soil, soil water, and nutrient status commensurate with intended resource utilization strategies.

6. Development of integrated pest management programs, including chemical, biological, and mechanical approaches, for major range sites infested with undesirable plant species.

7. Determine the impact of integrated range ecosystem management strategies on water-use efficiency, water yield, and water quality.

8. Develop management criteria to improve the efficiency of water-use on arid and semi-arid Southern Plains range ecosystems.

9. Determine the seed production potential, quantity and quality of forage produced, grazing strategy, persistence of stand, and red meat producing potential of improved plant materials.

10. Determine the nutritional status of the diets of range animals on important range sites to elucidate factors limiting red meat production and develop criteria for plant materials improvement.

11. Develop integrated management strategies for range ecosystems cognizant of (a) physiological, morphological, and production characteristics of dominant species, (b) multiple uses of range resources, (c) relationship of related resources, and (d) stabilization and optimization of ranching operations.

12. Determine the utility of remote sensing techniques for range condition and trend analysis and for determination of rangeland response to stresses such as drought.

B. Research Teams:

The following discussion outlines additional scientific personnel needed to complete the research teams as described in previous sections. These individuals are needed to implement the recommendations and to close the research gaps presented in Section V. The scientific composition of the research teams and the present staffing of those research teams can be found in Table 2. Those scientists not present are also indicated, and these are reflected in this section.

1. <u>Forage Improvement - College Station, El Reno, Temple, and Woodward</u>:

   Additional expertise is needed in agronomy, range science, and animal nutrition to round out the forage improvement research program in the Oklahoma-Texas Area of the Southern Plains Region. These additional scientists would allow establishment of new efforts with forbs, legumes, shrub, and grass species. Additional support is needed to evaluate the nutritional value and agronomic and range science values of new plant materials.

2. <u>Management Systems - College Station, El Reno, Temple, and Woodward</u>:

   Integrated research to develop management systems for range and complementary forage crops requires on-site coordinated studies involving many disciplines. To complete the staffing pattern for a management systems research team, expertise is needed in range science, agronomy, synecology, engineering, and biology.

3. Revegetation - College Station, El Reno, Temple, and Woodward

The current revegetation team should be strengthened by an additional expertise in soil science, agricultural engineering, range science, and agronomy. Such increased staffing would result in considerable progress being made towards increasing livestock forage production, wildlife habitat, watershed benefits, and recreational opportunities on the diverse range sites by enhancement of the vegetation.

4. Brush and Weed Management - College Station and Temple

Additional expertise is needed in areas of agricultural engineering, entomology, range science, plant pathology, ecology, and chemistry to enhance the brush and weed management research program. This additional expertise would be directed toward emphases on biological control of undesirable plants, development of electrostatic spray charging systems for aircraft and equipment for dispensing pelleted herbicides from aircraft, introduction of new herbicides, and development of new ways of using both new and old herbicides for improved brush and weed control. Although considerable effort has been directed toward brush and weed management in the Southern Plains, the problem remains a severe one requiring continued emphasis.

5. Water Management - Durant-Chickasha and Temple

Range science expertise is needed to complete the water management team to properly investigate the interrelationships of water yield and quality to rangeland management strategies.

6. Soil-Plant-Water Relations - Bushland, Temple, and Woodward

This team needs, in addition to the soil scientists and agricultural engineers presently available, expertise in agronomy, range science, and plant pathology. It is possible that this expertise could be obtained by cooperative efforts with other SEA-AR units. Soil-plant-water relations should be investigated on native range and improved pastures to evaluate grazing systems and livestock responses to precipitation use efficiency and the nutrient status of soils.

7. Plant-Animal Relations - El Reno and Woodward

Additional expertise is needed in the areas of animal science and agronomy to complete the plant-animal relations team. Emphasis should be placed on determination of the genetic potential of grazing animals and their relationship to the varied environments in which they exist.

8. Remote Sensing - Weslaco

Expertise should be involved in remote sensing work that

includes range science, soil science, agricultural engineering, and agronomy. This expertise is presently covered, although additional expertise in agronomy would be helpful. Perhaps this could be obtained by cooperation with other SEA-AR units to investigate the utility of using high altitude sensors to monitor changes in vegetation composition resulting from imposing range management strategies and implementing range improvement practices at various locations.

VII. References

Austin, M. E. 1972. Land resource regions and major land resource areas of the United States. USDA Agricultural Handbook 296. 82+ p.

Bailey, R. G. 1976. Ecoregions of the United States. Forest Service, U.S. Department of Agriculture, Ogden, Utah. Map.

Forest Service. 1972. The nation's range resources--a forest-range environmental study (FRES). USDA Forest Resource Report 19. 147 p.

Heady, H. F. 1975. Range Management. McGraw-Hill, New York.

Lewis, James K. 1973. Improving the efficiency of calf production in the 80's using resources of the Great Plains: An educator's view. In: Baker, Frank H., Ed., Great Plains Beef Symposium. Great Plains Agricultural Council and American National Cattlemen's Association, University of Nebraska, Lincoln, Nebraska.

Merkel, D. L. et al. 1974. Plant materials. Rep., Range Rehabilitation and Equipment Work Conference, Tucson, Arizona. 20 p.

Appendix A. Forest-rangeland types, conditions, and stocking rates, and production in the Oklahoma Texas Area, Southern Plains Region.[1/]

Ecosystem	Area OK	Area TX	Area Total	Condition (US) Good	Fair	Poor	Very Poor	Grazed (US)	Stocking Rate (US)	Total Stocking[2/] Present	Potential
	1,000,000 Acres			%				%	AUM/a	1,000 AUM's	
Shinnery	0.6	2.5	3.1	16.5	27.7	40.5	15.3	97	0.406	1,200	4,400
Plains Grasslands	4.9	31.4	36.3	14.7	34.2	39.6	11.5	98	0.294	10,500	34,900
Prairie	3.8	9.3	13.1	14.0	34.2	38.1	13.7	95	1.090	13,600	47,500
Longleaf-slash pine	0.0	0.3	0.3	--	--	--	--	96	0.200	60	120
Loblolly-shortleaf pine	0.9	4.5	5.4	--	--	--	--	37	0.011	20	40
Oak-pine	0.7	2.6	3.3	--	--	--	--	48	0.105	170	340
Oak-gum-cypress	0.8	1.9	2.7	--	--	--	--	3	2.490	200	400
Elm-ash-cottonwood	0.1	0.2	0.3	--	--	--	--	10	0.213	10	20
Wet Grasslands	0.0	0.9	0.9	17.0	27.6	20.7	34.7	79	0.663	500	2,300
Desert shrub	0.0	<0.1	<0.1	8.4	24.7	50.5	16.4	93	0.091	0	0
Southwestern shrub-steppe	0.0	16.3	16.3	10.5	14.8	41.5	33.2	92	0.084	1,300	6,500
Desert Grasslands	0.0	2.7	2.7	8.4	24.7	50.5	16.4	93	0.091	200	900
Texas Savanna	0.0	28.4	28.4	16.4	23.5	45.9	14.2	99	0.428	16,500	43,700
Oak-hickory	2.2	4.5	6.7	--	--	--	--	28	0.253	500	1,000
TOTAL	14.0	105.5	119.5							44,760	142,120

[1/]Partially obtained from and based on "An Assessment of the Forest and Range Land Situation in the United States" (Forest Service FS-345, 1908).

[2/]Present stocking = (total area) x (% grazed) x (AUM/a). Potential stocking calculated from FRES by assuming good, fair, and poor condition range can produce 75, 40, and 15%, respectively, of maximum. Potential not calculated for types lacking condition data, but based on the ecosystems having condition data, we can assume that it could be doubled.

Appendix B. Livestock and animal units in the Oklahoma-Texas Area, Southern Plains Region.[1/]

Class of livestock	Number Oklahoma	Number Texas	Number Total	Animal Units[2/] Oklahoma	Animal Units Texas	Animal Units Total
	1,000 head			1,000 units		
Beef cows	2,259	6,482	8,741	2,259	6,482	8,741
Replacement heifers	328	1,000	1,328	230	700	930
Bulls	107	438	545	134	548	682
Calves under 500 lb	1,604	4,279	5,883	642	1,712	2,354
Total cattle	4,298	12,199	16,497	3,265	9,442	12,707
Ewes	49	1,865	1,914	10	373	383
Wethers and rams	3	87	90	1	22	23
Lambs	7	408	415	1	41	42
Total sheep	59	2,360	2,419	12	436	448
TOTAL				3,277	9,878	13,155

[1/]From 1977 Agricultural Statistics.

[2/]1 heifer = 0.7 AU; 1 bull = 1.25 AU; 1 calf = 0.4 AU; 1 ewe = 0.2 AU; 1 wether or ram = 0.25 AU; 1 lamb = 0.1 AU.

Appendix C. Estimated numbers of big game in the Southern Great Plains (from the American Hunter 6(8):101-104, 1978).

Species	Number (000's)			Animal Units (000's)[1/]		
	Oklahoma	Texas	Total	Oklahoma	Texas	Total
Whitetail deer	95	3,000	3,095	23.8	750	773.8
Elk	1.0	0.7	1.7	0.7	0.5	1.2
Pronghorn Antelope	----	14.7	14.7	----	2.5	2.5
Cougar	----	0.3	0.3	----	-----	-----
Total				24.5	753.0	777.5

[1/] 1 elk = .67 AU; 1 deer = .25 AU; 1 pronghorn = .17 AU (Heady, H. F. 1975. Range Management. McGraw-Hill, New York).
NOTE: The white tail deer in Texas are probably more like .15 AU.

Appendix D. Some potential seeded species[1/] for the Oklahoma-Texas Area, Southern Plains subregion.

Scientific name	Common name
Agropyron smithii	Western wheatgrass
Andropogon gerardii	Big bluestem
Andropogon hallii	Sand bluestem
Andropogon scoparius	Little bluestem
Bothriochloa caucasicus	Caucasian bluestem
Bothriochloa ischaemum	Yellow bluestem
Bouteloua curtipendula	Sideoats grama
Buchloe dactyloides	Buffalograss
Chloris gayana	Rhodesgrass
Cynodon dactylon	Bermudagrass
Elymus canadensis	Canada wildrye
Eragrostis curvula	Weeping lovegrass
Eragrostis superba	Wilman lovegrass
Eragrostis trichodes	Sand lovegrass
Leptochloa dubia	Green sprangletop
Panicum antidotale	Blue panic
Panicum coloraturm	Kleingrass
Panicum virgatum	Switchgrass
Paspalum dilatatum	Dallisgrass
Paspalum notatum	Bahiagrass
Pennisetum ciliare	Buffelgrass
Sorghastrum nutans	Indiangrass

[1/] Data based largely on Merkel et al., 1974.

Appendix E. Research information available and needed for various categories of range scientists based on a survey of scientists working in the Oklahoma-Texas Area, Southern Plains Region.

Item	Category	Research information available 1/	Research needs 1/
I.	Inventory and Classification	1.6	3.2
	A. Census of:		
	1. Vegetation	2.0	3.8
	2. Forage utilization	2.0	3.8
	3. Soil stability	1.0	3.0
	4. Animal populations	1.0	1.0
	5. Animal movements	1.0	1.0
	6. Weather	2.5	3.6
	B. Determination of Range Trends	1.8	4.0
	C. Site Potential	1.8	4.0
	D. Assessment of Annual Forage Crops	1.8	4.3
	E. Land Use	1.7	3.6
II.	Improved Plants	1.7	3.9
	A. Germplasm:		
	1. Collection	1.8	3.8
	2. Preservation	1.8	4.3
	3. Species relationships	1.8	4.2
	B. Evaluate Adaptability	1.8	4.2
	C. Breeding:		
	1. Stress	1.7	4.6
	2. Photosynthetic efficiency	1.7	2.7
	3. Quality and quantity	1.8	4.7
	4. N-fixation	1.4	3.7
	5. Disease and insect resistance	1.4	3.8
	6. Water use efficiency	1.9	3.9
	D. Seed Production	2.0	3.4
III.	Revegetation	1.9	4.4
	A. Availability of Plant Materials	1.8	4.1
	B. Germination	2.0	4.0
	C. Seedling Establishment	2.0	4.8
	D. Methods	2.0	4.7
	E. Grazing Adaptability	1.8	4.3
IV.	Ecology, Damage, and Control of Pests	1.6	3.9
	A. Unwanted Plants (noxious, poisonous)	2.0	3.9
	B. Diseases	1.8	4.0
	C. Nematodes	1.5	5.0
	D. Insects	1.0	4.0
	E. Rodents	1.7	3.3
	F. Rabbits	1.7	4.3
V.	Other Manipulative Treatments	2.0	3.4
	A. Fertilization	2.0	3.0
	B. Mechanical Treatments (ripping, furrowing, etc.)	2.0	3.7
	C. Moisture Conservation	2.0	4.2
	D. Development of Animal Water	2.0	2.5
	E. Burning	1.8	3.8
VI.	Complementary Pastures	1.9	4.5
	A. Seasonality	1.8	4.3
	B. Quantity and Quality	2.0	4.8

Appendix E. (Continued)

Item	Category	Research information available 1/		Research needs 1/	
VII.	Grazing Systems		1.6		4.0
	A. Proper Utilization	1.5		4.0	
	B. Stocking Rate	1.5		3.5	
	C. Time of Grazing	1.5		4.5	
	D. Native Range Alone	1.5		3.5	
	E. Native Range plus Complementary Pastures	2.0		4.7	
	F. Native Range plus Manipulated Range	1.5		4.0	
	G. Manipulated Range	1.5		3.5	
VIII.	Effects of Practices III-VII On:		1.7		4.1
	A. Water Quality and Quantity	1.8		4.2	
	B. Moisture Conservation	1.7		4.3	
	C. Erosion and Sedimentation	1.5		4.0	
	D. Range Ecology	2.0		4.0	
	E. Animal Performance and Behavior	1.7		4.0	
IX.	Livesetock		1.6		3.7
	A. Diet and Nutrition	1.7		4.3	
	B. Performance	2.0		4.3	
	C. Trampling	1.5		3.0	
	D. Behavior	1.5		3.5	
	E. Distribution	1.5		3.5	
X.	Wildlife		1.5		3.1
	A. Population	1.5		3.0	
	B. Diet	1.5		3.0	
	C. Habit	1.5		3.0	
	D. Distribution	1.5		3.0	
	E. Wildlife-Livestock Relations	1.5		3.5	
XI.	Basic Range Research		2.0		4.8
	A. Plant	2.0		4.5	
	B. Plant-Environment Interactions	2.0		4.9	
	C. Water Use by Plants	1.9		4.9	
	D. Plant-Animal Interactions	1.8		4.8	
	E. N-fixation	1.8		4.4	
XII.	Models				
	A. Analysis		1.8		4.3
	1. Prediction	2.0		4.7	
	2. Identification	1.5		4.0	
	3. Detection of research needs	2.0		4.0	
	B. Synthesis or Simulation	1.8		4.4	
	C. Management	1.7		4.8	

1/ Research available: Adequate = 3; inadequate = 2; none = 1.
Research need: High = 5; high-medium = 4; medium = 3; medium-low = 2; low = 1.

Appendix F. Ecosystems researched by each scientist in the Oklahoma-Texas Area, Southern Plains Region.

Location and scientist	Ecosystems 1/ A	B	D	E	F	G	H	I	Total
WOODWARD									
Dewald	0.20	0.80							1.00
Sims	0.20	0.60					0.20		1.00
Coyne	0.50	0.50							1.00
Berg	0.50	0.50							1.00
TEMPLE									
Brewer	0.60	0.40							1.00
Burnett				0.50					0.50
Burson	0.50	0.20		0.30					1.00
Chichester	0.40			0.60					1.00
DeLoach	0.12	0.02		0.35	0.45	0.06			1.00
Engelke	0.60	0.40							1.00
Hauser	0.40	0.60							1.00
Mayeux	0.40	0.10		0.50					1.00
Swanson	0.40	0.10		0.50					1.00
Tishler	0.40	0.20		0.40					1.00
Voigt		0.40			0.15		0.30	0.15	1.00
Richardson	0.10	0.10							0.20
Williams	0.10	0.05							0.15
COLLEGE STATION									
Baur	0.25	0.25	0.50						1.00
Bouse	0.15	0.15	0.15	0.15					0.60
Bovey	0.20	0.50	0.15	0.15					1.00
Carlton	0.15	0.15	0.15	0.15					0.60
Meyer	0.25	0.25	0.25	0.25					1.00
Bashaw	0.10	0.10	0.30	0.50					1.00
WESLACO									
Everett				0.90	0.10				1.00
Gonzalez				0.20	0.80				1.00
BUSHLAND									
Eck		0.20							0.20
CHICKASHA									
Allen		0.50	0.50						1.00
Nicks		0.25	0.25						0.50
Schoaf		0.25	0.25						0.50
Welch		0.25	0.25						0.50
Naney		0.05	0.05						0.10
DURANT									
Menzel		0.20							0.20
Rhodes		0.50							0.50
Smith		0.30							0.30
Davis		0.30							0.30
EL RENO									
Bokhari		1.00							1.00
Horn		0.30							0.30
STILLWATER									
Ahring		0.50							0.50
TOTAL	6.52	10.97	2.80	5.45	1.50	0.06	0.50	0.15	27.95

1/ A = prairie grassland; B = plains grasslands; D = oak-hickory; E = Texas savanna; F = Southwestern shrub-steepe; G = desert grasslands; H = shinnery; I = desert shrub.

Appendix G. Range research categories for each scientist in the Oklahoma-Texas Area, Southern Plains Region.

Location and scientist	CATEGORIES[1/]												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
WOODWARD													
Dewald		0.90	0.10										1.00
Sims				0.10	0.10	0.20	0.20		0.30			0.10	1.00
Coyne		0.20					0.20				0.60		1.00
Berg		0.20					0.20				0.60		1.00
TEMPLE													
Brewer			1.00										1.00
Burnett					0.12			0.38					0.50
Burson		0.70									0.30		1.00
Chichester			0.40		0.40			0.20					1.00
DeLoach	0.04			0.48				0.48					1.00
Engelke		0.90		0.10									1.00
Hauser			1.00										1.00
Mayeux				1.00									1.00
Swanson				0.50							0.50		1.00
Tishler		0.60									0.40		1.00
Voigt		1.00											1.00
Richardson												0.20	0.20
Williams												0.15	0.15
COLLEGE STATION													
Baur			0.10					0.05			0.85		1.00
Bouse				0.60									0.60
Bovey				0.50							0.50		1.00
Carlton				0.60									0.60
Meyer				0.50							0.50		1.00
Bashaw		1.00											1.00
WESLACO													
Everitt	0.30	0.20		0.25						0.25			1.00
Gonzalez	0.10	0.10	0.25		0.25				0.15	0.15			1.00
BUSHLAND													
Eck		0.20											0.20
CHICKASHA													
Allen											0.50	0.50	1.00
Nicks												0.50	0.50
Schoaf												0.50	0.50
Welch												0.50	0.50
Naney												0.10	0.10
DURANT													
Menzel											0.10	0.10	0.20
Rhodes											0.25	0.25	0.50
Smith											0.15	0.15	0.30
Davis											0.15	0.15	0.30
EL RENO													
Bokhari		0.40				0.40			0.20				1.00
Horn						0.20			0.10				0.30
STILLWATER													
Ahring		0.50											0.50
TOTAL	0.44	6.90	2.85	4.63	0.87	0.80	0.60	1.11	0.73	0.40	5.40	3.20	27.95

1/ Research Categories: I = inventory and classification; II = improved plants; III = revegetation; IV = ecology, damage, and control of pests; V = other manipulative treatments; VI = complementary pastures; VII = grazing systems; VIII = effects of practices III - VII; IX = livestock; X = wildlife; XI = basic research; XII = models.

Appendix H. Assignment of scientists to various research teams as shown in Table 3 of Range Research Assessment in the Oklahoma-Texas Area, Southern Plains Region.

A. Forage Improvement

WOODWARD		
Dewald	Agronomist	.80
Vacancy	Agronomist	1.00
TEMPLE		
Burson	Plant Geneticist	1.00
Engleke	Plant Geneticist	.90
Tischler	Plant Physiologist	.94
Voigt	Plant Geneticist	.90
COLLEGE STATION		
Bashaw	Plant Geneticist	1.00
STILLWATER		
Ahring	Agronomist	.50
EL RENO		
Bokhari	Agronomist	.70

Summary (SY's)

SCIENTISTS	PRESENT	VACANCIES
Agronomist	2.00	1.00
Plant Geneticist	3.80	
Plant Physiologist	.94	
Total SY's	6.74	1.00

B. Management Systems

WOODWARD		
Sims	Range Scientist	0.80
Coyne	Plant Physiologist	1.00
Vacancy	Range Scientist	(funded) 1.00
Vacancy	Synecologist	1.00
Vacancy	Biologist	1.00
Vacancy	Agronomist	1.00
Berg	Soil Scientist	0.30
TEMPLE		
Burnett	Soil Scientist	0.10
COLLEGE STATION		
Baur	Plant Physiologist	0.10
Bouse	Agricultural Engineer	0.06
Bovey	Agronomist	0.10
Carlton	Agricultural Engineer	0.06
Meyer	Plant Physiologist	0.10
EL RENO		
Bokhari	Agronomist	0.30

Summary (SY's)

SCIENTISTS	PRESENT	VACANCIES
Range Scientist	0.80	(funded) 1.00
Agronomist	0.60	1.00
Plant Physiologist	1.20	
Synecologist		1.00
Biologist		1.00
Soil Scientist	0.30	
Agricultural Engineer	0.12	
Total SY's	3.12	4.00

C. Revegetation

TEMPLE		
Brewer	Agricultural Engineer	1.00
Chichester	Soil Scientist	0.20
Dewald	Agronomist	0.20
Engelke	Plant Geneticist	0.10
Ticshler	Plant Physiologist	0.06
Voigt	Plant Geneticist	0.10

Summary (SY's)

SCIENTISTS	PRESENT	VACANCIES
Soil Scientist	0.20	
Plant Geneticist	0.20	
Agricultural Engineer	1.00	
Plant Physiologist	0.06	
Total SY's	1.46	

D. Brush and Weed Control

COLLEGE STATION		
Baur	Plant Physiologist	0.90
Bouse	Agricultural Engineer	0.54
Bovey	Agronomist	0.90
Carlton	Agricultural Engineer	0.54
Meyer	Plant Physiologist	0.90
TEMPLE		
Mayeux	Agronomist	0.80
DeLoach	Entomologist	1.00
Swanson	Plant Physiologist	1.00

Summary (SY's)

SCIENTISTS	PRESENT	VACANCIES
Plant Physiologist	2.80	
Agronomist	1.70	
Agricultural Engineer	1.08	
Entomologist	1.00	
Total SY's	6.58	

E. Water Management

TEMPLE		
Burnett	Soil Scientist	0.20
Mayeux	Agronomist	0.20
Richardson	Agricultural Engineer	0.20
Williams	Hydraulic Engineer	0.15
DURANT-CHICKASHA		
Allen	Hydraulic Engineer	1.00
Nicks	Agricultural Engineer	0.50
Schoaf	Hydraulic Engineer	0.50
Welch	Soil Scientist	0.50
Naney	Geologist	0.10
Menzel	Soil Scientist	0.20
Rhodes	Agricultural Engineer	0.50
Smith	Soil Scientist	0.30
Davis	Microbiologist	0.30

Summary (SY's)

SCIENTIST	PRESENT	VACANCIES
Agronomist	0.20	
Agricultural Engineer	1.20	
Hydraulic Engineer	1.65	
Geologist	0.10	
Microbiologist	0.30	
Soil Scientist	1.20	
Total SY's	4.65	

F. Soil-Plant-Water Relations

WOODWARD		
Berg	Soil Scientist	0.70
TEMPLE		
Chichester	Soil Scientist	0.80
Hauser	Agricultural Engineer	1.00
BUSHLAND		
Eck	Soil Scientist	0.20

Appendix H. (Continued)

	Summary (SY's)	
SCIENTISTS	PRESENT	VACANCIES
Soil Scientist	1.70	
Agricultural Engineer	1.00	
Total SY's	2.70	

G. Plant-Animal Relation

WOODWARD		
Sims	Range Scientist	0.20
Vacant	Animal Scientist	1.00
EL RENO		
Horn	Animal Scientist	0.30

	Summary (SY's)	
SCIENTISTS	PRESENT	VACANCIES
Range Scientist	0.20	
Animal Scientist	0.30	1.00
Total SY's	0.50	1.00

H. Remote Sensing

WESLACO		
Everitt	Range Conservationist	1.00
Gonzalez	Soil Scientist	1.00
TEMPLE		
Brewer	Agricultural Engineer	0.20

	Summary (SY's)	
SCIENTIST	PRESENT	VACANCIES
Range Conservationist	1.00	
Soil Scientist	1.00	
Agricultural Engineer	0.20	
Total SY's	2.20	

REPORTS IN THIS SERIES

Evans, R. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Great Basin and Northwest. 1980. SEA-AR range research in the Great Basin and Northwest (Idaho, Nevada, Oregon, Utah, and Washington). Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

Herbel, C. H., P. L. Sims, W. A. Laycock, R. J. Lorenz, R. A. Evans, K. G. Renard, SEA-AR Rangeland Scientists in the 17 Western States, R. F Barnes, and G. E. Carlson, National Program Staff Scientists. 1980. Range research, an assessment of current problems and a strategy for the future: A summary of range research by SEA-AR in the 17 western states. Agricultural Research, Science and Education Administration, U. S. Department of Agriculture. 18 pages.

Laycock, W. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Central Great Plains. 1980. SEA-AR range research in the Central Great Plains (Colorado, Kansas, Nebraska, and Wyoming). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

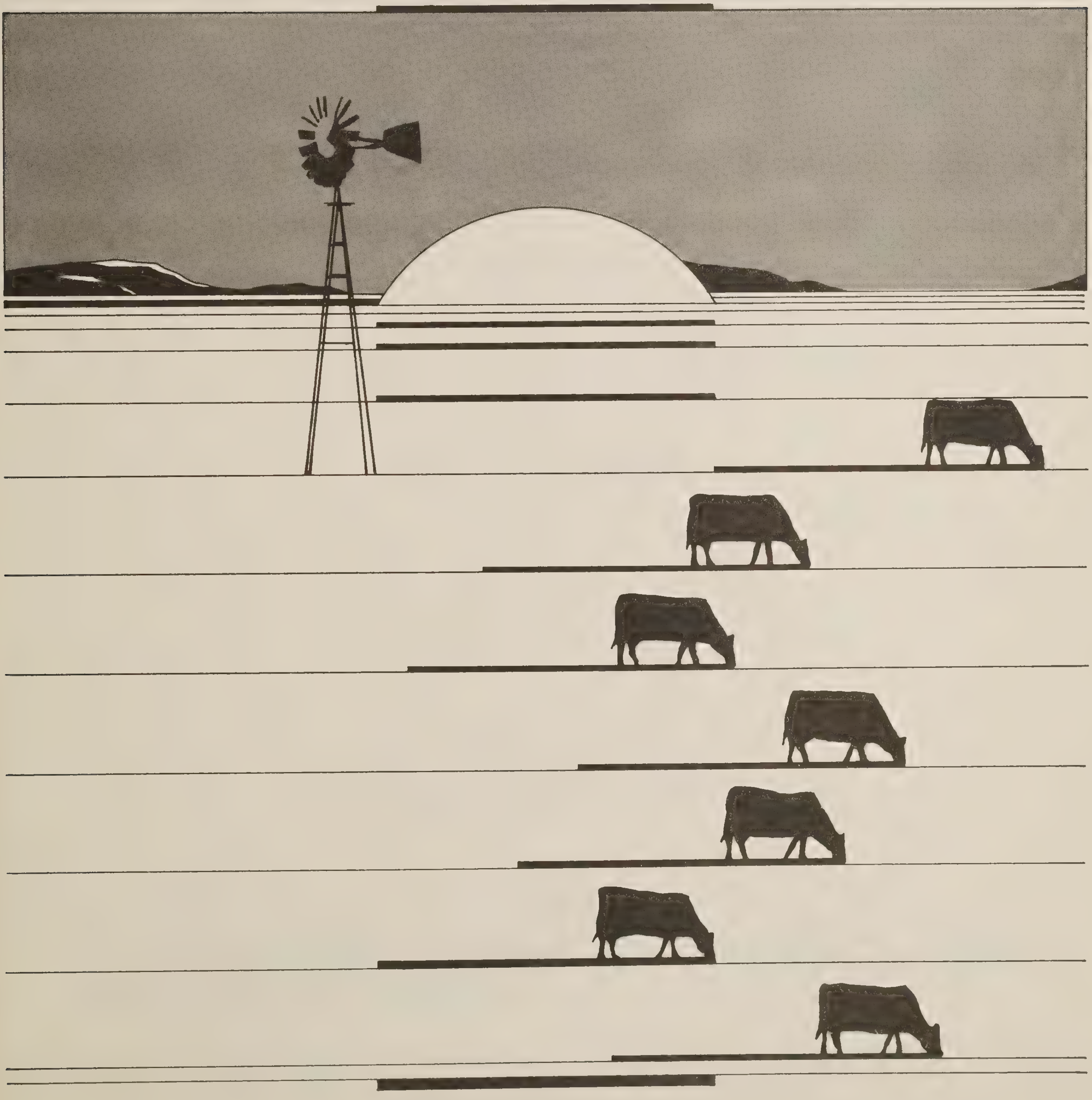
Lorenz, R. J., J. R. Wight, R. J. Kartchner, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Northern Great Plains. 1980. SEA-AR range research in the Northern Great Plains (Montana, North Dakota, and South Dakota). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Renard, K. G., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southwest. 1980. SEA-AR range research in the Southwest (Arizona, California, and New Mexico). Agricultural Research, Science and Education Administration, U. S. Deparment of Agriculture.

Sims, P. L., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains. 1980. SEA-AR range research in the Southern Great Plains (Oklahoma and Texas). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

SEA-AR Range Research Assessment

Southwest



United States Department of Agriculture
Science and Education Administration
Agricultural Research

RANGE RESEARCH

An Assessment of Current Problems

and

A Strategy for the Future

SOUTHWEST SUBREGION

New Mexico, Arizona, California

Prepared by

Kenneth G. Renard, Carlton H. Herbel, and SEA-AR Forage and Range Scientists in the Southwest Subregion and Robert F Barnes and Gerald E. Carlson, National Program Staff Scientists.

CONTENTS

SEA-AR Range Research

Southwest Region

(New Mexico, Arizona, California)

I. The Situation

The Southwest, consisting of New Mexico, Arizona, and California, is a highly diverse area with appreciable variations in climate, topography, vegetation, soils, and land ownership in a short distance. Eastern New Mexico is dominated by plains grasslands. The lower elevations of Arizona and New Mexico are dominated by desert grasslands, southwestern shrub-steppe and desert shrub. These latter three ecosystems are also prevalent in western Texas and northern Mexico. In addition to desert shrub, the lower elevations of California also have annual grasslands. The mid elevations of New Mexico, Arizona, and California have pinyon-juniper, mountain grasslands, chaparral-mountain shrub, and ponderosa pine. The higher elevations of the three states are primarily forested ecosystems. Federally owned land comprises 45, 44, and 34%, respectively, of the total land in Arizona, California, and New Mexico (Stoddart et al., 1975).

Groundwater mining for irrigation has led to declining water levels to the point where irrigation is economically marginal. Abandonment of the irrigated land is producing problems of revegetation with range species. In addition, an overabundance of unwanted plants (brush and weeds) is drastically reducing forage production and increasing soil erosion.

The ecosystems as defined by the FRES study (U.S. Forest Service, 1972) are listed in Appendix A for each state. Appendix A also includes estimates of the percentage of each ecosystem in "Good", "Fair", and "Poor" range condition, the percentage of each ecosystem grazed, the stocking rate of livestock (animal unit months (AUM's) per acre), and the present and potential stocking. Most of these stocking figures are based on the FRES study for the entire ecosystem. Therefore, these figures are distorted for some specific states, but the figures show that, overall, range improvement could more than double the present stocking.

According to 1977 Agricultural Statistics, there are in excess of 3.5 million beef cattle in the three states and 1.6 million sheep (Appendix B). About 84% of the livestock numbers shown in Appendix B are accounted for in the livestock grazing on forest-range ecosystems shown in Appendix A. The remaining 16% of the livestock shown in Appendix B probably obtain their feed from nonrange sources.

Appendix C shows the estimated numbers of big game animals in the three states. These animals represent a total of 269,300 animal units. Also, large numbers of nongame species make use of range. These include rabbits, rodents, and many other small animals.

II. Problems and Trends

Returns on ranching investments are less than desirable, and range improvement practices requiring additional capital are difficult to make with the high interest rates on borrowed money. However, increased values of rangelands are resulting in greater attention to the importance of this resource.

Trends in the region include increasing demand on rangeland for uses associated with the astronomical population increases in the region. The primary uses associated with the population increase, particularly near population centers, are for recreational activities such as hunting, hiking, and travel with off-road vehicles. This latter use, primarily on fragile government lands, leads to severe environmental problems such as erosion, denudation of vegetation, and increasing dust problems.

There is a strong demand in the area for additional water to provide the M&I (municipal and industrial) water needs, and it is anticipated that some of this water may ultimately come from water harvesting or vegetation manipulation to enhance surface runoff from land areas presently used for forage production. In some areas, the rangeland is internally drained and does not provide much usable water to downstream uses. The population increases also are resulting in appreciable conversions of rangelands to urban uses. Many subdivisions developed by land speculators have been made with poor layout of roads and municipal services with a subsequent problem of environmental deterioration. While there is an increasing demand for recreation and water, much of the rangeland will continue to be used for animal production.

California annual rangelands are characterized by a Mediterranean climate whose precipitation is out-of-phase with favorable temperatures for plant growth. However, rainfall is usually sufficient for fairly high productivity, especially on the more favorable sites. Carrying capacity is directly related to slope and canopy cover of trees varying from 2.0 aum's/acre on slopes of 0 to 5% with tree cover of 0-25% to 0.1 aum's/acre on 40% slopes with tree cover of 50 to 100% (McDougald, unpublished data, Univ. of California Extension Service). Forage producing throughout the three-state region is generally restricted by low nitrogen levels in the soil and forage quality, especially protein level, is low because of generally low amounts of legumes in the stand.

Forage production in Arizona and New Mexico rangelands is also restricted by limited precipitation although, in contrast to California, more of the rainfall occurs during periods when the temperatures are favorable for plant growth. Desirable plant species must have high drought tolerances because the potential evaporation is many times the annual precipitation. In addition, many storms occur as intense convective thunderstorms with high runoff, so that much of the annual rainfall is lost for potential forage production. This variable precipitation also results in a highly variable forage crop from rangelands.

An increasingly common trend in the region involves abandoning irrigated lands because of increasing energy costs for lifting groundwater from ever increasing depths and the transfer of water rights from irrigation to other

uses such as those of municipal and industrial uses. These abandoned lands frequently need revegetation efforts to (1) provide adequate forage for animals, (2) reduce dust problems which persist from these cultivated areas until adequate vegetation is established, and (3) improve the esthetics of such areas (the first vegetation succession often involves Russian thistle). Problems on such areas may often involve excessive salinity levels which lead to soil sealing and the need for salt tolerant grasses.

III. Researchable Problems and Goals

As might be expected for an area where precipitation is generally deficient, highly variable temporally and spatially, and soils generally of insufficient depth to store the limited amount of moisture, moisture conservation is a widespread problem. Research to define systems for infiltration enhancement, water spreading, or improving the water use efficiency of vegetation species are very researchable problems. The need for moisture conservation is especially acute during revegetation activities on deteriorated range sites. The success of many seeding efforts is based on the availability of soil moisture, and any research which can enhance making the moisture available should be actively pursued.

A. Research Needs

The questionnaires completed by SEA-AR scientists working in range related activities in the region gave some insight to research needs. Weighting the replies on the basis of the urgency of the need (e.g. high = 5 and low = 1) for the 12 categories provided the following information for the region.

1. Basic research is needed on plants, plant-environment interactions, and water use by plants.

2. Plant-animal interactions and nitrogen fixation research is needed.

3. Plant breeding for drought tolerance and manipulative treatments which conserve moisture are needed as well as the effect of such programs on off-site conditions.

4. Determining range site potentials for inventory and classification purposes is needed.

5. The effects of various range practices on range ecology was identified as a high priority need. Such research would be consistent with environmental protection, a pressing need on the public trust lands in the region.

6. There is a need to develop wildlife-livestock relations where both are using the same land area.

7. Models of range systems are needed for predicting the effects of varying range uses and plans.

8. Plant breeding emphasizing stress tolerance, photosynthetic efficiency, N-fixation, and disease and insect resistance was identified as a high priority need for improving forage productions.

9. Development of grazing systems to ensure proper utilization, stocking rates, and season of grazing were identified.

10. Wildlife populations, diet, habit, and distribution were also identified as researchable topics necessary to ensure that rangeland resources are efficiently used in a multiple use sense.

Other items identified by individual scientists include:

1. Determine the ecology associated with the control of unwanted plants and rodents.

2. Determine the diet, nutrition, and distribution of livestock.

3. Study the physiology and ecology of plants.

4. Increase the availability of plant materials for revegetation.

5. Determine the effects of livestock trampling on infiltration and erosion.

6. Develop environmental simulation models to predict resource changes resulting from varying land use. The models must include all facets of the abiotic cycle and provide for simulation of research/ conservation options.

7. Range caterpillar, desert termites, grasshoppers, and harvester ants are insect problems persisting in the region.

Appendix E summarizes the weighted response from the scientists working in range related problems. There may be some bias among the 12 major categories because of a preponderance of replies from specialists in any one category. The high rankings in many categories, however, should afford a valid assessment of the problem's importance.

Increasing protein level of forage on annual ranges in California can most effectively be accomplished by introducing annual clovers into the plant communities. Research has been conducted on dates of planting and the most adapted cultivars of rose and subclovers. Seeding of these clovers has been carried out on many of the foothill ranges. Research is needed to determine if these clovers can be seeded on the drier areas of central California and to establish soil-vegetation relations in terms of seeding success. To insure consistent success of clover establishment and growth, studies should

be conducted to identify and assess relative importance of sources of stress that limit germination, establishment, and symbiotic nitrogen fixation of these legumes.

The purpose of these studies is to investigate previously unexplored forms of biologic and physical interactions including those of allelopathy and competition that induce stress to annual clovers.

B. Research Teams

Range research problems are amenable to team research approaches involving people from various academic disciplines (Appendix H). Teams identified for research include:

1. Forage Improvement
2. Revegetation
3. Brush and Weed Management
4. Water Management
5. Plant-Animal Relations
6. Management Systems Development
7. Remote Sensing
8. Plant-Soil-Water Relations
9. Socio-Economic Relations
10. Insects, Diseases, and Nematodes
11. Plant-Induced Animal Disorders

An alternate scheme would involve teams for abiotic, producers, consumers, and decomposers.

For the Southwest Region, four teams are identified as being on the highest priority. Team one would have technical expertise in Revegetation and Brush and Weed Management; Team 2 in Water Management; Team 3 would include Plant-Animal Relations and Management Systems Development; and Team 4 to work with Forage Improvement. Remote Sensing was also identified as a promising research activity for the Region and should become a future research thrust area.

IV. Current Research Effort

Appendices F and G summarize the distribution of scientific effort in range

research in the three-state region on the basis of the Research Topic Areas and Ecosystems, respectively. The 13.75 SY Effort (FY 1979) is divided at one location in each state.

A. Research Locations

Research locations in the three-state Southwest Region are centered one per state with the exception that the scientific team in Reno, NV has experimental locations in California. Similarly, insect control problems applicable to conditions encountered in the region are centered with the Insect Laboratory at Bozeman, MT. Locations of scientists and field experiments have been superimposed on a Land Resource Map of the three-state area in Figure 1. Specific details for individual locations follow:

1. Tucson, Arizona

The Southwest Rangeland Watershed Research Center consists of a staff of 7 SY's. Only 3 SY's are identified in Appendices F and G because much of the work is associated with other aspects of water management. Major field activities are at the Walnut Gulch Experimental Watershed near Tombstone, Arizona, the Santa Rita Experimental Range south of Tucson, and the Experimental Range at Ft. Stanton, New Mexico.

a. Mission. The mission of the Center is to study the hydrology of rangeland watersheds and the effects of changing land uses and practices on the hydrologic cycle. This includes the rainfall, which is natural input to the watersheds; the quality and movement of water on the surface and below the surface; erosion from the watersheds and channels within the watersheds; sedimentation within the channels and reservoirs; and the present and potential uses of available water. Primary emphasis is on:

* Understanding and evaluating the effects of changing land use, including range renovations and conservation practices, and

* Developing the principles for such understanding in order to apply the results and findings from research areas to areas having little or no research data.

Center scientists use the data from experimental areas in Arizona and New Mexico to study the quality and quantity of water from southwestern rangelands. Information obtained from these rangeland watersheds is used to determine their present and future water resource potentials which include managing the use of the water for competing local and downstream users; establishing soil, water, and grazing management systems for increasing and stabilizing forage produc-

tion, providing design concepts and criteria for flash flood and sedimentation control, and monitoring the movement of nonpoint source pollutants on semiarid rangelands. Simulation models are developed and used to transfer data and ideas to ungaged areas.

The research team includes hydrologists, hydraulic engineers, soil scientists, a geologist, a mathematician, and support personnel including secretaries, clerks, and maintenance personnel.

b. Land Resource Region and Area (Austin, 1972):

Tucson Headquarters Santa Rita Experimental Range	Western Range and Irrigated Region (D)
Walnut Gulch Experimental Watershed	Southeastern Arizona Basin and Range (41)
Ft. Stanton Experimental Range	Western Range and Irrigated Region (D)
	Arizona and New Mexico Mountains (39)

c. Climate (Average):

Tucson: Precipitation averages 11 inches annually with winter and summer peaks on the annual distribution. Snow is only occasional, but increases with elevation. The average annual monthly temperature varies from 50° to 86° F with an annual average of 67.3° F.

Santa Rita Experimental Range: Precipitation varies with elevation between about 12" and over 20". The bimodal distribution of this annual precipitation is nearly evenly distributed between the summer monsoon season (convective thunderstorms) and the more gentle winter season (frontal storms). The temperature varies between a minimum monthly value of 47° F in January and December to 79° F in July with an average annual value of 63.1° F. The frost-free season averages 237 days.

Walnut Gulch Experimental Watershed (Tombstone): The long term average annual value of precipitation is 14" with almost 2/3 occurring during the summer monsoon season. Almost all runoff results from the summer storms. Annual average monthly temperature varies from a minimum of 47° F in January and December to 79° F in July, with an average annual value of 63.1° F. The frost-free season averages 237 days.

Fort Stanton Experimental Range (Capitan): The annual precipitation of 14.8" contains a summer peak in July, but less high

intensity storms occur here than in some other parts of New Mexico. The average annual temperature is 52° F with a frost-free season of 143 days.

d. Ecoregion (Bailey, 1976):

Tucson, the Santa Rita Experimental Range, and the Walnut Gulch Experimental Watershed are in the Mexican Highlands Shrub Steppe Ecoregion. Fort Stanton is in the Grama-Galleta Steppe, Juniper-Pinyon Woodland Mosaic of the Colorado Plateau.

e. Ecosystems (Forest Service, 1972):

Southern Arizona locations are in the Desert Shrub, while Fort Stanton is Pinyon-Juniper.

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Southeastern Arizona:

Creosotebush-Bursage

Franseria dumosa, white bursage
Larrea divaricata, creosotebush

Others:

Acacia greggii, catclaw acacia
Cercidium floridum, blue paloverde
C. microphyllum, yellow paloverde
Dalea californica, California dalea
D. spinosa, smokethorn dalea
Encelia farinosa, white brittlebrush
Ferrocactus acanthodes, California barrel-cactus
Hilaria rigida, big galleta
Lycium brevipes, wolfberry
Olneya tesota, tesota
Opuntia spp., cactus
Prosopis juliflora var. veluntina, velvet mesquite

g. Objectives:

(1) Refine the air-earth interface concept for predictive and operational point infiltration control; develop implements for imprinting infiltration control geometrics and determine optional surface and subsurface routing of rainwater for seed germination, seedling establishment, and for plant growth, utilize the new implements to improve conventional range management systems, and test the new management systems for water-use efficiency.

(2) Develop environmental simulation models to predict resource changes resulting from varying land use. The models must include all facets of the hydrologic cycle, erosion/sedimentation, and the transport of agricultural chemicals, and provide for a simulation of resource changes resulting from different management options.

(3) Use water harvesting techniques to improve stock water supplies and to increase forage production.

(4) Develop improved water erosion prediction and control to preserve and increase productivity and prevent water degradation, evaluate sediment transport, yield, and properties, and improve stabilization of stream channels and control of gullies.

(5) Develop precipitation/infiltration models having monthly probabilities to enable simulation of soil moisture for plant seeding and forage yield to improve in a probabilistic sense ultimate times for seeding based on seed germination water requirements for different native and introduced species.

h. Status:

(1) The air-earth interface concept for controlling rainwater infiltration and the land imprinter are recent developments that result in more efficient use of precipitation.

(2) Environmental simulation models have progressed to the point where they are fairly successful for midwestern U.S conditions. The hydrologic part of these models works fairly well in arid areas, as does the erosion, but the chemical transport work is only now being initiated.

(3) Water harvesting catchments of asphalt-fiberglass increase range water supply, and forage yields can be increased 2-4 times by using runoff-farming techniques.

(4) Developed improved total load sampler for unattended operation on small watersheds; applied the Universal Soil Loss Equation to semiarid rangelands; developed a simulation model involving partial differential equations for water movement and sediment detachment and transport.

(5) Precipitation simulation models for individual storms (depth and aerial extent) have been developed. Coupling to soil moisture status and seed germination water requirement work has not begun.

i. Plans:

Basic research on infiltration control will be accelerated,

which will include quantification of the air-earth interface concept on various soils for further application of the land imprinter. Nonpoint pollution investigations are being pursued to permit definition of best management practices under a variety of land use and management plans. Seed germination requirements for plant establishment are being pursued to couple with precipitation/soil moisture models which should enable predicting optimum seeding times, etc.

j. Opportunities and Needs:

Some of the major range research needs are: 1) study species relationships of germplasm and evaluate adaptability and improve resistance to stress, nitrogen fixaton, and water-use efficiency of range plants, 2) revegetation research emphasizing seedling establishment, methods, and adaptability to grazing, 3) effects of manipulative treatments on hydrology, erosion, and sedimentation; 4) determine effects of livestock trampling on infiltration and erosion, 5) basic physiologic and ecologic research, and 6) models useful to range managers.

There is also a very pressing need to sample a wider range of the major land resource areas in the states of Arizona and New Mexico. The current limited watershed measurements are restricted to the hotter desert areas and ignores problems of major land resource areas like the Colorado and Green River Plateaus, among others.

2. Tucson, Arizona

The Aridland Grass Breeding Unit at Tucson is a 1 SY effort identified in Apendices F and G. Major efforts for the unit are conducted at the SCS Plant Materials Center in Tucson.

a. Mission: The mission of this research unit is to develop improved grass cultivars for the arid rangelands of the Southwest. Grass germplasm is acquired and evaluated for potential as source material to select and breed for improved adaptability to stress environments encountered in the Southwest. Improved cultivars may result directly from selections made among and within the plant species evaluated as well as from the crossing and breeding of promising germplasm types. The breeding program is supported by studies on mode of reproductions, genetic behavior, and the development of appropriate laboratory and growth chamber techniques for the evaluation of breeding materials.

The research unit consists of a plant geneticist and support personnel plus a graduate student(s) from the Plant Science Department of the University of Arizona.

b. Land Resource Region and Area (Austin, 1972):

Tucson and Santa Rita Experimental Range	Western Range and Irrigated Region (D)
	Southeastern Arizona Basin and Range (41)

c. Climatic (Average):

Tucson: Precipitation averages 11" annually with winter and summer peaks on the annual distribution. The average annual monthly temperature varies from 50° to 86° F with an average of 67.3° F.

d. Ecoregion (Bailey, 1976):

Mexican Highlands Shrub Steppe.

e. Ecosystems (Forest Service, 1972):

Desert Shrub.

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Southeastern Arizona:

Creosotebush-Bursage

Franseria dumosa, white bursage
Larrea divaricata, creosotebush

Others:

Acacia greggii, catclaw acacia
Cercidium floridum, blue paloverde
C. microphyllum, yellow paloverde
Dalea californica, California dalea
D. spinosa, smokethorn dalea
Encelia farinosa, white brittlebrush
Ferrocactus acanthodes, California barrel-cactus
Hilaria rigida, big galleta
Lycium brevipes, wolfberry
Olneya tesota, tesota
Opuntia spp., cactus
Prosopis juliflora var. veluntina, velvet mesquite

g. Objectives:

Identify critical needs for improvement of warm-season aridland grasses, study inheritance through selection and breeding, and

study plant responses through germination, establishment, and growth stages for use in stress environments.

h. Status:

Evaluation is underway of selected populations of blue panicgrass for carbon dioxide evolution. Research on the other objectives is also continuing.

i. Plans:

Isolate genotypes of blue panicgrass for studies of photosynthesis.

j. Opportunities and Needs:

The current program is not adequately supported and has been shored up in recent years through shifts from other programs and the use of special funds. The program is a high priority research need and probably might be combined most effectively with the Aridlands Ecosystems Improvement Group. This program has made very significant contributions in the past on grass selections, and there are other species like blue panicgrass, weeping lovegrass, Indian ricegrass, etc., in need of improvement. Such work is essential to both improving the forage production on the warm rangeland areas and for environmental enhancement such as can be achieved by improving soil cover to reduce erosion.

3. Tucson, Arizona

Arid Land Ecosystems Improvement Group - Brush Control and Seeding

a. Mission: Develop economical, reliable, and environmentally sound methods for control of unwanted plants on rangelands so that the quantity and quality of forage for domestic and wild animals is improved, the aesthetic values are enhanced, and livestock losses due to poisonous plants are reduced, develop and evaluate plant species on rangelands for livestock and wildlife, and to protect soil from wind and water erosion.

b. Land Resource Region and Area (Austin, 1972):

Tucson, Arizona

Western Range and Irrigated Region (D)
Central Arizona Basin and Range (40)

Flagstaff, Arizona

Western Range and Irrigated Region (D)
Colorado River Plateau (35)

c. Climatic (Average):

Tucson, Arizona

Precipitation: 5-20", summer and winter maximum, spring drought
Temperature: 60-74° F
Frost-free period: 225-300 days

Flagstaff, Arizona

Precipitation: 6-16", summer and winter maximum, spring drought
Temperature: 45-55° F
Frost-free period: 100-220 days

d. Ecoregion (Bailey, 1976):

Tucson, Arizona
Mexican Highlands Shrub Steppe

Flagstaff, Arizona
Colorado Plateau Woodlands-Sagebrush

e. Ecosystems (Forest Service, 1972):

Tucson, Arizona
Desert Shrub

Flagstaff, Arizona
Pinyon-Juniper

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Southern Arizona
Creosotebush-Bursage

Franseria dumosa, white bursage
Larrea divaricata, creosotebush

Flagstaff, Arizona
Juniper-Pinyon Woodlands

Juniperus monosperma, oneseed juniper
J. osteosperma, Utah juniper
Pinus monophylla, oneleaf pine

Others:

Agropyron smithii, western wheatgrass
Artemisia tridentata, big sagebrush

Bouteloua curtipendula, sideoats grama
B. gracilis, blue grama
Ceanothus spp.
Cercocarpus spp., mountain mahogany
Chrysothamnus spp., rabbitbrush
Cowania mexicana, cliffrose
Fallugia paradoxa, Apache plume
Juniperus deppeana, alligator juniper
J. occidentalis, western juniper
Oryzopsis hymenoides, Indian ricegrass
Purshia tridentata, antelope bitterbrush
Quercus emoryi, emory oak
Q. gambelii, gambel oak
Q. grisea, gray oak
Q. undulata, wavy-leaf oak
Sporobolus cryptandrus, sand dropseed

g. Objectives:

(1) Develop effective, safe, and economical methods for control of velvet mesquite, catclaw acacia, wait-a-minutebush, creosotebush, pricklypear cactus, cholla cactus, alfombrilla, and other unwanted shrubs and poisonous plants.

(2) Determine the effects of vegetation manipulation, stocking rates, grazing systems, and agricultural chemical applications on the quality and quantity of runoff water from rangeland watersheds.

(3) Determine the effects of herbicides and biological control entities on honey bees.

(4) Develop principles and practices for the establishment and maintenance of less valuable forage plants to prevent overgrazing.

(5) Determine the mineral nutrient concentrations and efficiencies of selected plants and evaluate the effect of improved nutrient status on establishment.

h. Status:

(1) Research to develop more effective controls for velvet mesquite and catclaw acacia will be continued. Tebuthiuron was found effective on creosotebush and wait-a-minutebush. Research on alfombrilla will be continued another four years.

(2) The watershed research will continue. Monitoring herbicidal residues (2,4,5-T) in soils and plants of the Jornada Experimental Range was initiated.

(3) Research on effects of herbicides will receive less attention than in the past.

(4) Studies to determine the impact of vegetation manipulation on wildlife will be initiated on the Buenos Aires Ranch in cooperation with the University of Arizona, Arizona Game and Fish Department, and Pruett-Wray Cattle Company.

(5) Preliminary studies suggest that boron, molybdenum, zinc, and phosphorus are critical nutrients for optimum forage production on some rangeland soils.

i. Plans:

Initiate research on remote sensing of alfombrilla and other range plants and rangeland seeding. Species establishment and adaptation will be investigated. The mineral nutrient levels of range plants will be studied in the greenhouse and field.

j. Opportunities and Needs:

Need technical assistance. Another problem is apathy of public and some hostility toward the use of agricultural chemicals on rangeland. Better drift control of sprays is needed. Accurate aircraft delivery systems for pelleted herbicides are desperately needed. Diversity of range sites. Animal scientists are not readily available to conduct necessary grazing and feeding studies.

Plant species needing improvement include Arizona cottontop, fourwing saltbush, Lehmann lovegrass, black grama, Boer lovegrass, alfalfa, Wrights buckwheat, blue panicgrass, alkali sacaton, and tobosa-grass.

The major range research needs are: 1) classify site potential for multiple uses, 2) evaluate adaptability and water-use efficiency of range plants, 3) increase availability of plant materials for revegetation, 4) develop manipulative treatments for moisture conservation, 5) determine proper utilization of range plants, and 6) develop prediction models of productivity for plants and animals.

4. Las Cruces, New Mexico

The Range Management Unit at Las Cruces has a staff of 5 SY's identified in Appendices F and G. Major field activities are located at the Jornada Experimental Range. The Jornada was established in 1912, and its 190,000 acres are controlled by SEA-AR. Continuous records of vegetation, stocking, and weather since 1915 form the basis for the various studies.

a. Mission: The mission of the unit is to improve the productivity and utilization of arid and semiarid southwestern rangelands while maintaining or improving the resource. This includes studies of the vegetation, animals, soils, and weather, and the relations among these factors. Primary emphasis is given to:

* Understanding the ecology and physiology of range plants and the effects of manipulative treatments on the ecology and physiology of these plants,

* Determining the performance, diets, and habits of range cattle,

* Managing water and erosional problems on rangelands, and

* Integrating all the available information into management practices.

Unit scientists also collaborate with an entomologist, a mammalogist, an ornithologist, and a soil microbiologist to obtain additional information on the effects of manipulative treatments on the range systems.

The research team includes range scientists, a plant physiologist, an animal scientist, a hydrologist, and support personnel including clerks and technicians.

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)
Southern Desertic Basins, Plains, and Mountains (42)

c. Climatic (Average):

Headquarters, Jornada Experimental Range

Precipitation: 9 inches summer maximum, spring drought
Temperature: 39° - 79° F
Elevation: 4,200 feet

d. Ecoregion (Bailey, 1976):

Chihuahuan Desert

e. Ecosystems (Forest Service, 1972):

Southwestern Shrub Steppe

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Grama-tobosa shrubsteppe

Bouteloua eriopoda, black grama
Hilaria mutica, tobosa
Larrea divaricata, creosotebush

Others:

Acacia constricta, whitethorn acacia
Andropogon barbinodis, cane bluestem
Aristida divaricata, poverty threeawn
A. longiseta, red threeawn
Astragalus spp., milkvetch or locoweed
Baileya multiradiata, desert baileya
Bouteloua curtipendula, sideoats grama
Flourensia cernua, tarbush
Gutierrezia sarothrae, broom snakeweed
Muhlenbergia porteri, bush muhly
Prosopis juliflora var. glandulosa, honey mesquite
*Sphaeralcea*spp., globemallows
Sporobolus airoides, alkali sacaton
S. flexuosus, mesa dropseed
Yucca baccata, Spanish dagger
Y. elata, soaptree yucca
Zinnia grandiflora, Rockymountain zinnia

g. Objectives:

(1) Determine cattle performance, diets, and habits to develop improved grazing systems.

(2) Develop range improvement practices for increasing productivity of rangelands.

(3) Determine the photosynthetic efficiency and other physiological criteria of important range plants for adaptation to grazing.

(4) Relate plant phenology with environmental parameters to maximize multiple uses of rangelands.

(5) Improve the utilization of water and decrease erosion and sedimentation.

h. Status:

(1) Initial phases to establish base line botanical, chemical, ethological, and weight change data from cattle grazing improved and unimproved arid rangeland.

(2) Several effective brush control-revegetation methods have been developed and evaluated under field conditions. Research has been initiated to study the effects of mesquite control and creosotebush control-seeding on productivity of plants and animals, on populations of insects,

rodents, and birds, and on micrometerology, soil erosion, and soil microbiology.

(3) Adaptation of some range plants to some range sites has been determined, but research on physiological criteria is just now underway.

(4) The various phenophases of the major range plants will be related to the micrometeorology of areas sprayed and not sprayed for mesquite control.

(5) A waterspreading scheme and a water ponding study are underway. Soil water, infiltration, and erodibility of various sites are being studied.

i. Plans:

Develop environmentally acceptable techniques to control mesquite, creosotebush, and tarbush, and revegetate depleted sites. Develop grazing management systems based on understanding ecological, ethological, and nutritional parameters. Emphasize more physiological research on range plants to determine tolerance levels of water stress, adaptation, and grazing pressure. Determine the proper integration of native and manipulated range for the various multiple uses of rangelands.

j. Opportunities and Needs:

Need a soil scientist, agricultural engineer, forage agronomist, animal physiologist, bioengineer, and plant breeder to conduct multidisciplinary research on: 1) water relations and crusting of some range soils, 2) microenvironment modification and methods of seeding, 3) grazing adaptability and seeding plants with stress tolerance; 4) livestock production on hot, arid rangelands, 5) quantitative ecology and modeling range systems, and 6) forb and shrub improvement for stress environments.

5. Albany, California

The biological weed control unit is a one SY effort identified in Appendices F and G.

a. Mission: The mission of the unit is to provide biological control of *Salsola iberica* and *Halogeton*.

b. Land Resource Region and Area (Austin, 1972):

California Subtropical Fruit Truck and Specialty Crop Region (C)
Central California Valleys (14)

c. Climate (Average):

Albany Headquarters

Precipitation: 12-30 inches, winter type, summer drought
Temperature: 55-62° F
Frost-free period: 250-365 days

Coalinga, Fresno County, CA

Precipitation: 7 inches, winter type, summer drought
Temperature: 63° F (minimum monthly 43° F, maximum 81° F)

Modoc County, CA

Precipitation: 15 inches, winter type, summer drought
Temperature: 47° F (minimum monthly 13° F, maximum 68° F)

d. Ecoregion (Bailey, 1976):

California chaparral

e. Ecosystem (Forest Service, 1972):

Mountain Grasslands

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Fescue-oatgrass

Carex tumulicola, sedge
Danthonia californica, oatgrass
Deschampsia holciformis, hairgrass
Festuca idahoensis, Idaho fescue

Sagebrush steppe (*Apropgron*-*Artmesia*)

g. Objectives:

(1) Assess impact of two introduced moths for *Salsola* control.

(2) Evaluate the impact of a weevil released to control *Salvia*.

(3) Assess impact of the moth, Coleophora parthenica, on *Salsola* and *Halogeton*.

h. Status:

(1) Both moths, *Coleophora parthenica* and *C. klimeschiella*, are well established and spreading. There has been some impact on target plants in a few locations.

(2) Weevil (*Phryciachus tan*) is established and increasing in number with some plant reductions now being visible in several pastures.

(3) The moth has become established on Salsola but not on the Halogeton. There is no measurable impact to date.

i. Plans:

The plans are to continue the search for natural enemies of undesirable plant species and to continue the evaluation of the current natural enemies being tested.

j. Opportunities and Needs:

The major range research needs for biological control are to study the ecology, damage, and control of insects and to determine the effects of manipulative treatments on range ecology.

6. Reno, Nevada

Two scientists (Evans and Young) at Reno conduct cooperative research with the professional staff at the University of California, Davis, on range improvement and range ecology. The research is primarily being conducted at the University of California's Sierra Foothills Range Field Station near Grass Valley, California. The SEA-AR research effort amounts to 0.25 SY's and has been primarily cooperative with UC, Davis, with some cooperative effort with the Pacific Southwest Forest and Range Experiment Stations, Forest Service at Fresno, California.

a. Mission: To study ecological relationships and to develop weed control and seeding techniques for improvement of annual grasslands for increased forage and livestock production.

Sierra Foothills Range Field Station (Browns Valley, California)

b. Land Resource Region and Area (Austin, 1972):

California Subtropical Fruit, Truck, and Specialty Crop Region (C)
Sierra Nevada Foothills (18)

Land Use: Production of livestock on range is the principal enterprise of the area.

Elevation: 500-2,500 feet

c. Climate (Average):

Precipitation: 12-40 inches, summers are dry
Temperature: 55-65° F
Frost-free period: 132-320 days

Soils: Noncalcic browns are dominant. Lithosols are common on the more sloping areas.

d. Ecoregion (Bailey, 1976):

Sierran Forest (M2610)

e. Ecosystem (Forest Service, 1972):

Oak woodland

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964) (See Reno in Northwest subregion):

g. Objectives:

(1) Monitor microenvironmental parameters, measure plant responses, and establish abiotic-biotic relationships, especially in defining seedbed conditions conducive for establishment of annual clovers and perennial grasses on annual rangelands.

(2) Study reproduction potentials, seed, and seedbed ecology of component species of annual rangelands, determine annual and year-to-year patterns of viable seed populations, and evaluate the effect of weather variation on reproductive potentials of annual species.

(3) Develop technology, including varieties, inoculum strains, date of planting, weed control, and seedbed preparation for successful establishment of rose and subterranean clovers into stands of annual grasses and broadleaf plants.

h. Status:

(1) Initial 3-year study has been completed on microenvironmental monitoring in relation to weed control and seeding on annual rangelands.

(2) Initial 5-year study has been completed on reproductive potentials and germinability of seeds in annual grasslands. Seed germination profiles in relation to temperature and moisture have been completed, and other studies on seed and seedbed ecology have been done.

(3) Studies involving dates of planting, methods of planting, inoculum techniques, and weed control for establishing rose and sub-clovers have been conducted.

i. Plans:

To develop further understanding of the dynamics of annual rangeland communities by studying spatial relationships among species and how seedbed characteristics affect these relationships.

To identify and assess the relative importance of sources of stress that condition germination, establishment, and symbiotic nitrogen fixation of annual legumes. The goal of this research is to develop more efficient and effective methodology for establishing legumes that fix significant amounts of nitrogen on annual rangelands.

j. Opportunities and Needs:

Excellent cooperation has been developed with scientists from the University of California, Davis, excellent facilities are at our disposal at the Sierra Foothills Range Field Station, representative rangeland and access to livestock for controlled grazing studies are also available at the station for our research.

Technical assistance and operating funds from SEA-AR would give us the opportunity to develop and expand a comprehensive project of range improvement and management of annual rangelands at the Sierra Foothills Range Field Station.

B. Research Teams

The needs of the Southwest for range related problem solving teams have been grouped into eight teams as enumerated in Appendix I. These teams and locations are:

Team	Subject	Location(s)
A.	Forage Improvement	Tucson, Las Cruces
B.	Management Systems	Las Cruces, Tucson
C.	Revegetation	Tucson, Las Cruces
D.	Brush and Weed Control	Albany, Las Cruces, Tucson
E.	Water Management	Tucson, Las Cruces
F.	Soil-Plant-Water Relations	Tucson, Las Cruces
G.	Plant-Animal Relations	Las Cruces, Tucson
H.	Remote Sensing	Las Cruces, Tucson

The present efforts on each of these teams are less than adequate for the size of the task to be researched. Furthermore, the effort of most of the scientists is divided between teams and often precludes making significant progress in many of the team needs because of the divided thrust. Such problems can be overcome only by additional support.

V. Research Gaps

Team A - Forage Improvement

Much work remains to understand the principals associated with forage

improvement in the arid and semiarid areas of the Southwest. Basic problems such as germplasm collection and preservation, problems of plant-breeding for stress tolerance, photosynthetic and water use efficiency, nitrogen fixation, disease and insect resistance, etc., are all essential to improving forage production. Further problems exist with regard to wide diversities of climate (wide temperature extremes, winter vs. summer rains, and variation in annual rainfall), the many different land resource areas and the associated soils within the three-state area, and finally, the establishment of forbs and browse species. The present effort, which is restricted to 1 SY, must be expanded to include agronomy, genetics, physiology, and microbiology. Emphasis must also be given to desirable forbs and shrubs that may be adapted in the Southwest.

Team B - Management Systems

Managing range ecosystems in such a way that the resource use is optimized for the many competing demands requires developing strategies which impact on watershed management, recreation, and wildlife management at the same time that we are able to ensure environmental preservation and enhancement. These strategies require knowledge of the morphological and physiological characteristics of the plants, animals, and the micro- and macro-climatic interrelationships.

Integrated research on range, forage, and environmental systems requires on-site coordinated studies involving such academic disciplines as range science, agronomy, plant physiology and ecology, soil science, animal science, biology, and engineering. The work also requires computer simulation to enable fitting the individual components of this very complex system in a definable way so that projections of cause/effect relations can be made on areas removed from the study areas. Such an approach is not being pursued on all elements of the problem at present in the Southwest region.

Team C - Revegetation

Basic research on the problems of establishing range plants is needed. The research, of necessity, should include plant nutritional needs, water requirements, and engineering aspects of seed application. Paramount to the success of such work is the need to develop analytical capability to predict the optimal times for seeding including the need for other inputs like nutrients for the climate and soil where the work is to be conducted.

Present efforts toward revegetation have been minimal, with much of the work being supplemental to other research thrusts. The reasons for this condition are not apparent, but may include the negative results concerning the economics of fertilizer applications on rangelands and the fact that water is often the single most limiting factor in revegetation, and thus, other elements of the problem limiting the success are overlooked. Semiarid grassland agriculture is sufficiently unique that information gathered from cultivated crops and pastures under wet climates or irrigation cannot be easily transferred without more basic knowledge of the rangeland ecosystem.

Team D - Brush and Weed Control

Integrated pest management has received increasing attention recently as an alternate to physical and chemical control of undesirable brush and weed species. Environmental concerns with the fate of many chemicals found to be effective in the past may lead to increasing restrictions on the use of some chemicals. Alternate means for such control are therefore essential to efforts for improving rangeland production of red meat.

In the short time-frame, chemicals hold the greatest promise for control of undesirable species. Important contributions can be made on the fate of herbicides following root uptake by both noxious and desirable species of range plants. Translocation and the various means of detoxification should be investigated. Contributions are also needed for the evaluation of water soluble and insoluble herbicides in relation to their ultimate disposition in runoff leaving an area.

In view of the trend toward soil-applied herbicides and their advantages over conventional sprays (less problem of drift to non-target areas), development of acceptable ground and aerial equipment for uniform distribution of these chemicals should be stressed.

Team E - Water Management

Water management is an essential factor in the success of many range related problems, especially so in the Southwest, where potential evaporation is many times larger than the precipitation. Furthermore, the nature of the meteorologic conditions in the region leads to great variations in the available moisture seasonally as well as between years. Thus, moisture stresses for forage production is severe, and in other instances, the inadequate distribution of drinking water for grazing animals can lead to an uneven distribution of the forage utilization within pasture systems. Research to overcome such problems requires interdisciplinary teams of range, soil, water, and animal scientists with analytical capability to develop models to facilitate transfer of principals developed from research sites to other locations throughout the region.

Water harvesting and spreading offers a great potential for increasing the animal carrying capacity of rangelands. The interrelationships of water and nutrient requirements and how management schemes can be used to increase and improve forage production on rangelands will, undoubtedly, be a fruitful research area in the future. Water harvesting/spreading can be used as a way to grow legumes on rangelands. Schemes for utilization of infiltration control must be researched in relationship to plant, animal, and soil conditions encountered throughout the heterogeneity of the region.

Recent legislation such as PL 92-500, the 1972 Clean Water Act, PL 95-192, the Soil and Water Resources Conservation Act, PL 95-217, the Rural Clean Water Act, as well as legislation requiring preparation of environmental impact statements on the grazing of public lands (PL 91-190, the National Environmental Policy Act of 1969), have added to the need for water management information, especially as to how they are affected by rangelands.

SEA-AR scientists are developing computer simulation models for addressing these problems, but the scarcity of data in the western United States is limiting the success with which these models can be used. Data on the effects of grazing systems, grazing intensity, conservation practices, etc., are practically nonexistent in the West, and especially in the Southwest region. In order to meet the societal objectives established by such legislation, experiments must be planned and completed to enable utilizing the models and, in some instances, in modifying the models to address the unique problems encountered in the region. One specific need for this modeling effort will be the addition of a submodel capable of simulating the grazing animal. Grazing animals represent a complex process that causes range and pasture systems to react sufficiently different from cropland areas that a special routine will be needed. Data from range watersheds will be needed to complete the validation and testing of such models.

Team F - Soil-Plant-Water Relations

It is difficult to separate water management problems from soil-plant-water relations. The latter, however, involves the treatment of soil moisture to a greater extent than the former. Nutrient cycling studies now nonexistent in the three-state Southwest region would be conducted on both native and improved range plants to determine plant requirements for optimum forage yield as well as defining the need for supplemental inputs. Work is also needed to develop nitrogen fixing plants for rangeland ecosystems and for incorporation in mixtures of improved grasses and forbs. Plant breeding work must be directed toward selections capable of withstanding stresses due to limitations of water, temperature, and plant nutrients as well as the excessive temperatures that may result during drought.

Team G - Plant-Animal Relations

The performance of both domestic animals and wildlife are often restricted by the availability of nutritious plants. The relationship of animals to the nutritional quality and quantity and the intake of native range and introduced plant species is an area where research and data are quite limited. Collection of such information will provide a basis for the development of range management systems. Consideration should be given to including animal scientists in the Tucson location to work with the water management and the aridlands ecosystems improvement groups.

Team H - Remote Sensing

The tremendous area in rangelands, and the need to inventory these resources, make remote sensing an ideal application. Efforts to date in using remote sensing technology have been miniscule. The success of such techniques in cultivated agricultural applications indicates the need for its application to rangeland problems.

Efforts must be made to use some of the expertise of SEA-AR locations such as the U.S. Water Conservation Laboratory in Phoenix and the Soil and Water Conservation Research Center at Weslaco, Texas. Their experience and expertise should allow rapid advance to range-related problems such as those

associated with mapping, assessing soil moisture, determining brush control effectiveness with herbicides, measuring insect infestations, quantifying problems such as the extent of salinity,, tracking wildlife movement, etc.

VI. Recommendations

Analytical treatment of range problems must be used to a greater extent than is presently being done. Creation of a modeling team for range problems must be utilized to overcome many of the shotgun approaches popular in range work heretofore. For example, development of a physically based model of a range ecosystem could be used to design experiments to test hypothesis used in the model. Furthermore, the range system is much too complicated to treat in any comprehensive way without a model, and the simulation capability which a model affords is essential. Such an effort would further facilitate directing our dwindling resources for such work in directions having the potential for immediate pay-off. Such a modeling effort must be an integral part of other range-related research and must be done by scientists with modeling capability working directly with plant, soil, water, and animal scientists. Inclusion of such capability with field scientists from the inception of the research will enable designing of the experiments to acquire all necessary data required for model validation.

Forage improvement efforts are also a very high priority need for the three-state region. Although some research of this type is being done in the State Agricultural Experiment Stations, the speed with which it is progressing is not sufficient to solve the problems that are present. Stresses due to temperature, moisture, and limited plant nutrients are unique enough in the region that reliance cannot be made for new plants or better selections from existing teams at Temple, TX and Logan, UT.

Water management efforts in the region are also of high priority. The present distribution of field data precludes treatment of the problems in many of the major land resource areas. For example, examination of Figure 1 illustrates this problem of poor distribution of field information for model validation.

Brush and weed management are facing especially acute problems because of the increasing withdrawal of the license for application of the chemicals which do the best for control of undesirable plant species. New chemicals, as they are developed, must be tested for their persistence in the environment, their potential for creating pollution problems, and the success they have in controlling noxious species. Biological control of such pests must be researched at an accelerated rate both from an economic standpoint and for the environmental consideration.

VII. References

Austin, M. E. 1972. Land Resource Regions and Major Land Resource Areas of the United States. Agric. Handbook 296, USDA, SCS, 82 pp.

Bailey, R. G. 1976. Ecoregions of the United States. USDA, Forest Service.

Forest Service. 1972. The Nation's Range Resources. USDA Forest Reosurces Rep. 19. 147 pp.

Forest Service. 1980. An Assessment of the Forest and Range Land Situation in the United States. U.S. Dep. Agric. FS-345. 631 p.

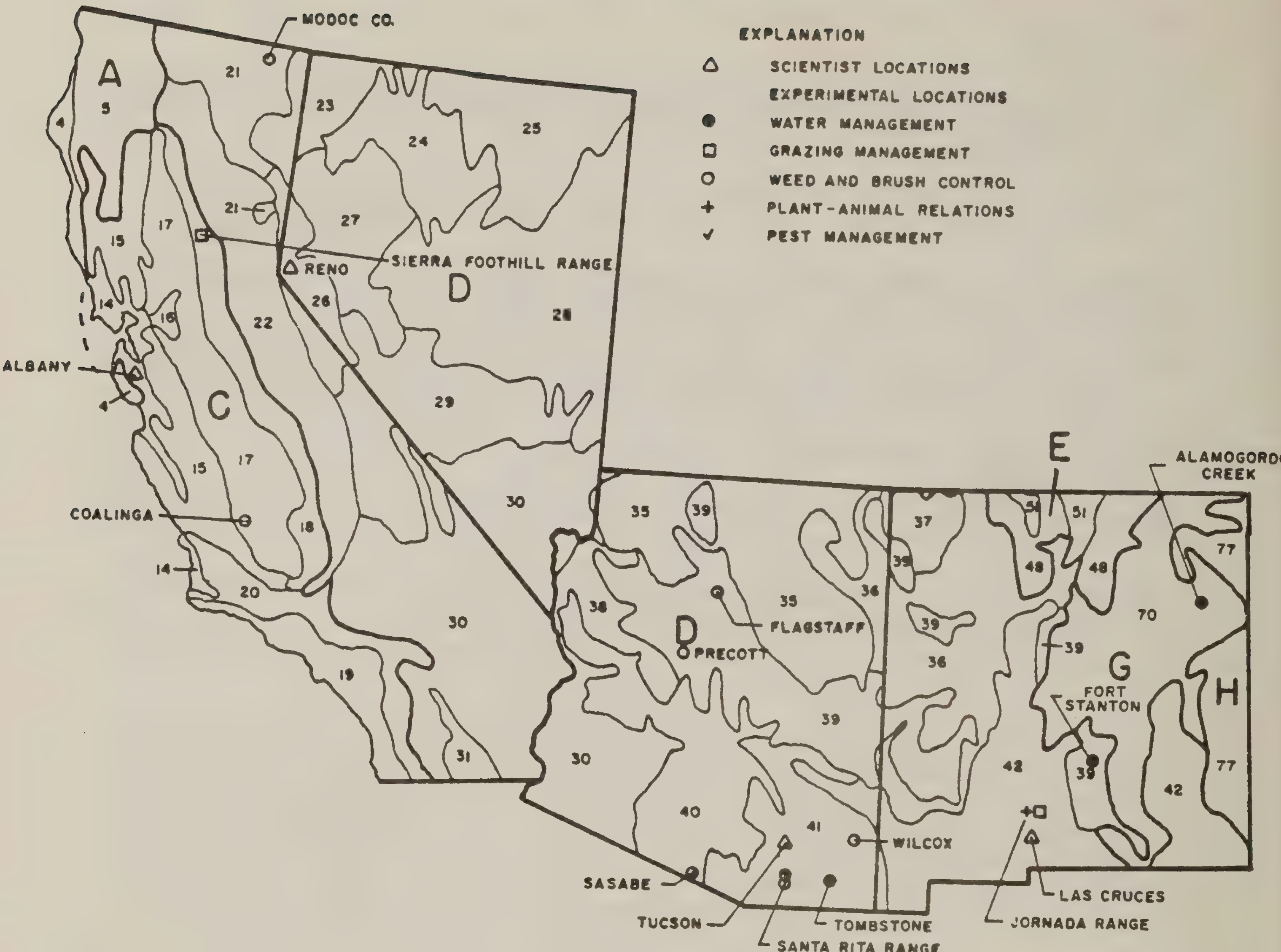
Kuchler, A. W. 1964. Potential Natural Vegetation of the Conterminous United States. Amer. Geogr. Soc. Spec. Publ. 36. 38 pp.

Merkel, D. L. et al. 1974. Plant Materials. Subcommittee Report of Range Rehabilitaton and Equipment Work Conference. Tucson, Ariz. 20 pp.

Pifer, D. 1978. NRA Game Survey. Amer. Hunter 6(8):101-104.

Reed, A. D. 1974. The Contribution of Range to the Economy of California. Univ. of Calif. Ext. Leaflet MA-82.

Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. Range Management. McGraw-Hill Book Co., 3rd edition.



A NORTHWESTERN FOREST, FORAGE, AND SPECIALTY CROP REGION

4 CALIFORNIA COASTAL REDWOOD BELT
5 SISKIYOU-TRINITY AREA

C CALIFORNIA SUBTROPICAL FRUIT, TRUCK, AND SPECIALTY CROP REGION

14 CENTRAL CALIFORNIA VALLEYS
15 CENTRAL CALIFORNIA COAST RANGE
16 CALIFORNIA DELTA
17 SACRAMENTO AND SAN JOAQUIN VALLEYS
18 SIERRA NEVADA FOOTHILLS
19 SOUTHERN CALIFORNIA COASTAL PLAIN
20 SOUTHERN CALIFORNIA MOUNTAINS

D WESTERN RANGE AND IRRIGATED REGION

21 KLAMATH AND SHASTA VALLEYS AND BASINS
22 SIERRA NEVADA RANGE
23 MALHEUR HIGH PLATEAU
24 HUMBOLDT AREA
25 OWYHEE HIGH PLATEAU
26 CARSON BASIN AND MOUNTAINS
27 FALLON-LOVELOCK AREA
28 GREAT SALT LAKE AREA
29 SOUTHERN NEVADA BASIN AND RANGE
30 SONORAN BASIN AND RANGE
31 IMPERIAL VALLEY

D

35 COLORADO AND GREEN RIVERS PLATEAU
36 NEW MEXICO AND ARIZONA PLATEAUS AND MESAS
37 SAN JUAN RIVER VALLEY MESAS AND PLATEAUS
38 BLACK, HUALPAI, AND CERBAT MOUNTAINS
39 ARIZONA AND NEW MEXICO MOUNTAINS
40 CENTRAL ARIZONA BASIN AND RANGE
41 SOUTHEASTERN ARIZONA BASIN AND RANGE
42 SOUTHERN DESERTIC BASINS, PLAINS AND MOUNTAINS

E ROCKY MOUNTAIN RANGE AND FOREST REGION

48 SOUTHERN ROCKY MOUNTAINS
51 HIGH INTERMOUNTAIN VALLEYS

G WESTERN GREAT PLAINS RANGE AND IRRIGATED REGION

70 PECOS-CANADIAN PLAINS AND VALLEYS

H CENTRAL GREAT PLAINS WINTER WHEAT AND RANGE REGION

77 SOUTHERN HIGH PLAINS

Figure 1. Land Resource Map and Location of Research Facilities in SEA-AR.

Appendix A. Rangeland types, areas, conditions, and stocking in the Southwest[1/]

Ecosystem	Area				Condition (US)				Grazed (US)	Stocking Rate (US)	Total Stocking[2/]	
	NM	AZ	CA	Total	Good	Fair	Poor	Very Poor			Present	Potential
	-------1,000,000 acres-------				--------------%--------------				%	AUM/a	---1,000 AUM's----	
Sagebrush	1.7	4.7	6.3	12.7	12.3	36.1	35.0	16.6	89	0.182	2,100	7,600
Desert Shrub	0.3	22.5	19.6	42.4	17.4	36.4	31.5	14.7	70	0.041	1,200	4,200
SW Shrub-steppe	19.3	7.6	0.0	26.9	10.5	14.8	41.5	33.2	92	0.084	2,100	10,700
Chaparral-mountain shrub	0.4	1.6	7.6	9.6	11.8	24.0	37.9	26.3	95	0.125	1,100	5,200
Pinyon-juniper	10.7	12.0	2.7	25.4	9.1	28.6	44.4	17.9	88	0.073	1,600	6,500
Mountain Grasslands	0.8	0.4	4.2	5.4	17.5	36.2	31.2	15.1	97	0.319	1,700	5,800
Mountain Meadows	<0.1	0.1	1.2	1.3	32.4	38.8	21.1	7.7	79	0.613	600	1,700
Desert Grasslands	10.9	9.9	0.0	20.8	8.4	24.7	50.5	16.4	93	0.091	1,800	6,900
Alpine	<0.1	0.0	1.4	1.4	42.8	27.1	28.7	1.4	70	0.045	40	100
Annual Grasslands	0.0	0.0	10.2	10.2	13.2	5.0	36.7	45.1	96	1.095	10,700	64,000
Shinnery	1.6	0.0	0.0	1.6	16.5	27.7	40.5	15.3	97	0.406	600	2,300
Plains Grasslands	14.1	0.0	0.0	14.1	14.7	34.2	39.6	11.5	98	0.294	4,100	13,600
Douglas Fir	1.3	0.2	3.2	4.7	--	--	--	--	52	0.049	120	240
Ponderosa Pine	4.2	4.1	7.8	16.1	--	--	--	--	74	0.059	700	1,400
Western White Pine	0.0	0.0	0.1	0.1	--	--	--	--	48	0.234	10	20
Fir-spruce	0.7	0.2	5.7	6.6	--	--	--	--	51	0.028	90	180
Hardwoods	0.4	0.2	4.2	4.8	--	--	--	--	56	0.059	160	320
Wet Grasslands	<0.1	0.0	0.1	0.1	17.0	27.6	20.7	34.7	79	0.663	50	260
Hemlock-sitka spruce	0.0	0.0	0.2	0.2	--	--	--	--	0	0.000	0	0
Lodgepole Pine	0.0	0.0	1.0	1.0	--	--	--	--	56	0.011	10	20
Redwood	0.0	0.0	0.8	0.8	--	--	--	--	55	0.063	30	60
Desert	<0.1	<0.1	0.1	0.1	76.6	11.5	6.5	5.4	45	0.001	0	0
TOTAL	66.4	63.5	76.4	206.3							28,810	131,100

[1/]Partially obtained from and based on, "An Assessment of the forest and Range Land Situation in the United States," (Forest Service FS-345, 1980).

[2/]Present stocking = (total area) x (% grazed) x (stocking rate). Potential stocking was calculated by assuming that good, fair, poor, and very poor conditions produced 80, 50, 30, and 10%, respectively, of potential. Based on the ecosystems with condition data, we assumed that the potential stocking for the remaining ecosystems could be doubled.

Appendix B. Livestock and animal units in the Southwest, 1977[1/]

Class of livestock	Number				Animal Units[2/]			
	NM	AZ	CA	Total	NM	AZ	CA	Total
	1,000 head				1,000 units			
Beef Cows	644	319	991	1,954	644	319	991	1,954
Replacement heifers	99	45	210	354	69	32	147	248
Bulls	43	20	39	102	54	25	49	128
Calves under 500 lb	406	173	590	1,169	162	69	236	467
Total beef cattle	1,192	557	1,830	3,579	929	445	1,423	2,797
Ewes	400	283	710	1,393	80	57	142	279
Wethers and rams	23	11	24	58	6	3	6	15
Lambs	77	54	91	222	8	5	9	22
Total sheep	500	348	825	1,673	94	65	157	316
Total					1,023	510	1,580	3,113

[1/] From Agricultural Statistics (1977).
[2/] 1 cow = 1.0 AU; 1 heifer = 0.7 AU; 1 bull = 1.25 AU; 1 calf = 0.4 AU; 1 ewe = 0.2 AU; 1 wether or ram = 0.25 AU; 1 lamb = 0.1 AU.

Appendix C. Estimated numbers of big game in the Southwest (from The American Hunter 6(8):101-104, 1978).

	Number				Animal Units[1/]			
	NM	AZ	CA	Total	NM	AZ	CA	Total
	1,000 head				1,000 units			
Bighorn sheep	0.8	3.0	0	3.8	0.2	0.6	0	0.8
Black bear	3.3	2.1	11.0	16.6	---	---	---	---
Mule deer	290.0	130.0	0	420.0	72.5	32.5	0	105.0
Whitetail deer	17.0	25.0	0	42.0	4.2	6.3	0	10.5
Blacktail deer	0	0	475.0	475.0	0	0	118.8	118.8
Javelina	1.2	30.0	0	31.2	--	--	--	--
Elk	27.0	10.5	3.7	41.2	18.0	7.0	2.5	27.5
Pronghorn antelope	26.0	7.5	5.8	39.3	4.4	1.3	1.0	6.7
Cougar	2.0	2.5	0	4.5	--	--	--	--
Total					99.3	47.7	122.3	269.3

[1/] 1 elk = .67 AU; 1 deer = .25 AU; 1 sheep = .20 AU; 1 pronghorn = .17 AU (Heady, H. F., 1975. Range Management. McGraw-Hill, New York).

Appendix D. Some potential seeded species in the Southwest[1/] [2/]

	NM	AZ	CA
Agropyron cristatum, Fairway wheatgrass	cm	cm	cm
A. desertorum, Crested wheatgrass	cm	cm	cm
A. elongatum, Tall wheatgrass	cd cm	cd cm	cd cm
A. intermedium, Intermediate wheatgrass	cd cm	cd cm	cd cm
A. riparium, Streambank wheatgrass	cd cm	cd cm	-- --
A. sibericus, Siberian wheatgrass	cd cm	cd cm	cd cm
A. smithii, Western wheatgrass	cd cm	cd cm	cd cm
A. trachycaulum, Slender wheatgrass	cm	cm	cm
A. trichophorum, Pubescent wheatgrass	cd cm	cd cm	cd cm
Alopecurus arundinaceous, Creeping foxtail	cd cm	cd cm	cd cm
Andropogon caucasicus, Caucasian bluestem	wd	wd	wd
A. gerardii, Bug bluestem	cm cd	-- --	-- --
A. hallii, Sand bluestem	cm cd, wd	cm cd, wd	-- --
A. scoparius, Little bluestem	cm cd, wd	-- --	-- --
Arrhenatherum elatius, Tall oatgrass	-- --	cd cm	cd cm
Astragalus cicer, Cicer milkvetch	cd cm	cd cm	cd cm
Atriplex canescens, Fourwing saltbush	cd cm, wd	cd cm, wd	cd cm, wd
Bothriochloa ischaemum, Yellow bluestem	cd wd	cd wd	cd wd
Bouteloua curtipendula, Sideoats grama	cd cm, wd	cd cm, wd	cd cm, wd
B. eriopoda, Black grama	cd wd	cd wd	-- --
B. gracilis, Blue grama	cd cm, wd	cd cm, wd	cd cm, wd
Bromus arvensis, Field brome	--	--	wm
B. biebersteinii, Meadow brome	cd cm	-- --	-- --
B. carinatus, California brome	--	--	wm
B. cartharticus, Rescuegrass	--	--	cd
B. inermis Smooth brome	cd cm	cd cm	cd cm
B. marginatus, Mountain brome	cd cm	cd cm	cd cm
B. mollis, Soft-chess	-- --	-- --	cd cm, wd
Cercocarpus montanus, Mountain mahogany	cd cm	cd cm	cd cm
Coronilla varia, Crown vetch	cd cm	cd cm	cd cm
Cowania mexicana, Cliffrose	cm	cm	cm
Dactylis glomerata, Orchardgrass	cd cm	cd cm	cd cm
Ehrharta calycina, Perennial veldtgrass	--	--	cm
Elymus cinereus, Basin wildrye	-- --	-- --	cd cm
E. glaucus, Blue wildrye	cd cm	cd cm	cd cm
E. junceus, Russian wildrye	cd cm	cd cm	cd cm
E. triticoides, Creeping wildrye	cd cm	cd cm	cd cm
Eragrostis atherstonei, Atherstone lovegrass	wd	wd	wd
E. chloromelas, Boer lovegrass	wd	wd	wd
E. curvula, Weeping lovegrass	cd wd	cd wd	cd wd
E. lehmanniana, Lehmann lovegrass	wd	wd	wd
E. superba, Wilman lovegrass	wd	wd	wd
E. trichodes, Sand lovegrass	cd wd	-- --	-- --
Eurotia lanata, Winterfat	cd cm	cd cm	cd cm

	NM	AZ	CA
Festuca arundinacea, Tall fescue	cd cm	cd cm	cd cm
F. idahoensis, Idaho fescue	-- --	-- --	cd cm
F. ovina var. duriuscula, Hard fescue	cd cm	cd cm	cd cm
F. rubra, Red fescue	-- --	-- --	cd cm
Hilaria jamesii, Galleta	cd cm	cd cm	cd cm
H. mutica, Tobosa	cd wd	cd wd	-- --
Lolium multiflorum, Italian ryegrass	--	--	wm
L. perenne, Perennial ryegrass	cd cm	cd cm	cd cm
Lotus tenuis, Narrowleaf trefoil	cm, wm	cm, wm	cm, wm
Midicogo sativa, Alfalfa	cd cm	cd cm	cd cm
Muhlenbergia wrightii, Spike muhly	cd cm	cd cm	-- --
Onobrychis viciaefolia, Sainfoin	cd cm	cd cm	cd cm
Oryzopsis hymenoides, Indian ricegrass	cd cm, wd	cd cm, wd	cd cm, wd
O. miliacea, Smilograss	--	wm	wm
Panicum antidotale, Blue panic	wd	wd	wd
P. coloratum, Kleingrass	wd	wd	--
P. virgatum, Switchgrass	cd, cm	cd, cm	cd, cm
Paspalum dilatatum, Dallisgrass	--	wd	wd
Pennisetum ciliare, Buffelgrass	--	wd	wd
Phalaris tuberosa, Harding grass	wm	wm	wm
Phleum pratense, Timothy	cd cm	cd cm	cd cm
Poa ampla Big bluegrass	cm	cm	cm
P. pratensis, Kentucky bluegrass	cd, cm wm	cd, cm wm	cd, cm wd, wm
P. secunda, Sandberg bluegrass	--	--	cm
Sporobolus airoides, Alkali sacaton	cd wd, wm	cd wd, wm	cd wd, wm
sorghastrum nutans, Indiangrass	cd cm	-- --	-- --
S. cryptandrus, Sand dropseed	cd, cm wd	cd, cm wd	cd, cm wd
Stipa comata, Needle-and-thread	cd wd	cd wd	cd wd
S. viridula, Green needlegrass	cd cm	cd cm	-- --
Trichachne californica, Arizona cottontop	--	wd	--
Trifolium fragiferum, Strawberry clover	--	--	cd, cm
T. repens, White clover	cd, cm	cd, cm	cd, cm

1/ From Merkel et al. (1974).
2/ Climatic zones of adaptation codes in each state:

cm = cold, moist winters
cd - cold, dry winters
wm = warm, moist winters
wd = warm, dry winters

Appendix E. Information available and research needed in the Southwest (based on a survey of SEA-AR scientists).

	Research information available 1/	Research Needs 1/
I. Inventory and Classification	2.1	3.1
A. Census of:		
1. Vegetation	2.0	3.5
2. Forage utilization	2.0	3.4
3. Soil stability	2.0	3.7
4. Animal population	2.0	2.5
5. Animal movements	2.0	2.0
6. Weather	2.5	2.9
B. Determination of Range Trends	2.0	3.3
C. Site Potential	2.0	4.6
D. Assessment of Annual Forage Crops	1.9	3.0
E. Land Use	2.5	2.2
II. Improved Plants	2.0	3.9
A. Germplasm		
1. Collection	2.1	3.1
2. Preservation	2.0	2.2
3. Species relationships	2.0	4.4
B. Evaluate Adaptability	2.0	4.5
C. Breeding		
1. Stress	2.1	4.5
2. Photosynthetic efficiency	2.1	4.03.
3. Quality and quantity	2.0	4.0
4. N-fixation	1.9	4.5
5. Disease and insect resdistance	1.9	3.5
6. Water use efficiency	2.1	4.5
D. Seed Production	2.1	3.6
III. Revegetation	2.1	3.9
A. Availability of Plant Materials	2.5	4.1
B. Germination	2.0	3.4
C. Seedling Establishment	2.0	3.9
D. Methods	2.0	3.9
E. Grazing Adaptability	2.0	4.4
IV. Ecology, Damage, and Control of Pests	1.8	3.0
A. Unwanted Plants	2.0	3.6
B. Diseases	1.5	2.1
C. Nematodes	1.5	2.1
D. Insects	1.6	3.0
E. Rodents	2.0	4.0
F. Rabbits	2.0	3.0
V. Other Manipulative Treatments	2.2	3.0
A. Fertilization	2.5	2.4
B. Mechanical Treatments (ripping, furrowing, etc.)	2.0	3.4
C. Moisture Conservation	2.0	4.1
D. Development of Animal Water	2.6	2.3
E. Burning	2.0	3.0

Appendix E. (Continued)

	Research information available 1/		Research Needs 1/	
VI. Complementary Pastures		1.6		2.5
A. Seasonability	1.6		2.5	
B. Quantity and Quality	1.6		2.5	
VII. Grazing Systems		2.0		
A. Proper Utilization	2.0		3.6	
B. Stocking Rate	2.0		3.1	
C. Time of Grazing	2.0		3.5	
D. Native Range Alone	2.0		3.6	
E. Native Range and Complementary Pasture	2.0		2.6	
F. Native Range and Mnaipulated Range	2.0		3.5	
G. Manipulated Range	2.0		3.6	
VIII. Effects of Practices III-VII On:		2.0		4.2
A. Water Quality and Quantity	2.0		4.0	
B. Moisture Conservation	2.0		4.6	
C. Erosion and Sedimentation	2.0		4.4	
D. Range Ecology	2.0		4.5	
E. Annual Performance and Behavior	2.0		3.5	
IX. Livestock		1.6		3.2
A. Diet and Nutrition	1.6		3.5	
B. Performance	1.6		3.0	
C. Trampling	1.6		3.7	
D. Behavior	1.6		2.7	
E. Distribution	1.6		3.1	
X. Wildlife		1.8		3.5
A. Population	1.6		3.4	
B. Diet	1.6		4.0	
C. Habit	2.0		2.9	
D. Distribution	2.0		2.8	
E. Wildlife-Livestock Relations	2.0		4.5	
XI. Basic Range Research		2.0		4.6
A. Plant	2.0		4.9	
B. Plant-Environment Interactions	2.0		4.9	
C. Water Use by Plants	2.0		4.9	
D. Plant-Animal Interactions	2.0		4.4	
E. N-fixation	2.0		4.0	
XII. Models				
A. Analysis		2.0		3.8
1. Prediction	1.9		4.1	
2. Identification	2.0		3.4	
3. Detection of research needs	2.0		3.4	
B. Synthesis or Simulation	2.0		3.5	
C. Management	2.0		4.4	

1/ Research Available: Adequate = 3; Inadequate = 2; None = 1.
2/ Research Need: High = 5; High-medium = 4; Medium = 3; Medium-low = 1.

Appendix F. Distribution of scientific range research efforts by ecosystems in the Southwest Region.

Location and scientist	ECOSYSTEMS[1/] C	F	G	I	J	K	L	M	N
Las Cruces									
Anderson			1.00						
Gibbens		1.00							
Herbel		0.50	0.50						
Sisson		0.50	0.50						
Tromble			1.00						
Tucson									
Dixon	0.10	0.20	0.40	0.20			0.10		
Frasier		0.15	0.15	0.15					0.15
Lane			0.25	0.25					
Renard			0.30	0.45					
Cox		0.30	0.30	0.40					
Johnsen				0.20	0.60				0.20
Morton		0.20	0.60	0.20					
Schreiber		0.30	0.30	0.40					
Wright			1.00						
Albany									
Andres	0.20		0.10	0.10		0.10		0.25	
TOTAL	0.30	3.15	6.40	2.35	0.75	0.10[2/]	0.10	0.25	0.35[2/]
								GRAND TOTAL	13.75[2/]

[1/] C = Sagebrush; F = Southwestern shrub-steppe; G = Desert grasslands; I = Desert shrub; J = Pinyon-juniper; K = Annual grasslands; L = Mountain meadows; M = Mountain grasslands; N = Chaparral-mountain shrub

[2/] Does not include 0.25 SY effort at Reno for Evans and Young.

Appendix G. Distribution of scientific effort for range research categories for the Southwest Region.

Location and scientist	RANGE RESEARCH[1/] I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Las Cruces												
Anderson	0.10						0.20		0.60	0.10		
Gibbens	0.15		0.05	0.02	0.18			0.25	0.05		0.25	0.05
Herbel			0.15	0.15	0.10		0.10	0.10	0.20		0.20	
Sisson		0.50									0.45	0.05
Tromble	0.16		0.05	0.01	0.25			0.40			0.08	0.05
Tucson												
Dixon			0.30	0.10	0.10			0.30			0.10	0.10
Frasier			0.30		0.45						0.10	0.10
Lane								0.50				
Renard								0.75				
Cox (1979)		0.20	0.40	0.10	0.10						0.20	
Johnsen		0.10	0.10	0.50				0.15			0.15	
Morton		0.05	0.10	0.60	0.05			0.10			0.10	
Schreiber	0.50		0.10	0.10							0.30	
Wright		0.90									0.10	
Albany												
Andres				0.55				0.20				
TOTAL	0.91	1.75	1.55[2/]	2.13[2/]	1.23	0	0.30	2.75	0.85	0.10	1.93	0.25[2/]
									GRAND TOTAL			13.75[2/]

[1/] Categories from Appendix E.

[2/] Does not include 0.25 SY effort from Reno for Evans and Young.

Appendix H. Assignment of scientists to various research teams in the Southwest

Team A. Forage Improvement	Title		SY
Tucson			
Wright	Agronomist		1.00
		Total	1.00

Team B. Management Systems	Title		SY
Las Cruces			
Anderson	Animal Scientist		0.20
Gibbens	Range Scientist		0.20
Herbel	Range Scientist		0.25
Sisson	Plant Physiologist		0.25
		Total	0.90

Team C. Revegetation	Title		SY
Las Cruces			
Gibbens	Range Scientist		0.05
Herbel	Range Scientist		0.15
Tromble	Hydrologist		0.05
Tucson			
Cox	Range Scientist		0.75
Dixon	Soil Scientist		0.30
Frasier	Hydraulic Engineer		0.30
Johnsen	Agronomist		0.10
Morton	Plant Physiologist		0.10
Schreiber	Soil Scientist		0.10
		Total	1.90

Team D. Brush and Weed Control	Title		SY
Las Cruces			
Gibbens	Range Scientist		0.05
Herbel	Range Scientist		0.15
Tucson			
Cox	Range Scientist		0.10
Dixon	Soil Scientist		0.15
Johnsen	Agronomist		0.60
Morton	Plant Physiologist		0.70
Schreiber	Soil Scientist		0.10
Albany			
Andres	Entomologist		0.75
		Total	2.60

Team E. Water Management	Title		SY
Las Cruces			
Gibbens	Range Scientist		0.15
Herbel	Range Scientist		0.10
Tromble	Hydrologist		0.50
Tucson			
Dixon	Soil Scientist		0.40
Frasier	Hydraulic Engineer		0.30
Johnsen	Agronomist		0.15
Lane	Hydrologist		0.50
Morton	Plant Physiologist		0.10
Renard	Hydraulic Engineer		0.75
		Total	2.95

Team F. Soil-Plant-Water Relations	Title	SY	
Las Cruces			
Gibbens	Range Scientistt		0.40
Herbel	Range Scientist		0.15
Sisson	Plant Physiologist		0.50
Tromble	Hydrologist		0.35

Tucson		
Cox	Range Scientist	0.15
Dixon	Soil Scientist	0.15
Frasier	Hydraulic Engineer	0.15
Johnsen	Agronomist	0.15
Morton	Plant Physiologist	0.10
Schreiber	Soil Scientist	0.60
	Total	2.70

Team G. Plant-Animal Relations	Title	SY
Las Cruces		
Anderson	Animal Scientist	0.80
Gibbens	Range Scientist	0.05
Herbel	Range Scientist	0.20
Sisson	Plant Physiologist	0.25
	Total	1.30

Team H. Remote Sensing	Title	SY
Las Cruces		
Gibbens	Range Scientist	0.10
Tromble	Hydrologist	0.10
Tucson		
Schreiber	Soil Scientist	0.20
	Total	0.40

REPORTS IN THIS SERIES

Evans, R. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Great Basin and Northwest. 1980. SEA-AR range research in the Great Basin and Northwest (Idaho, Nevada, Oregon, Utah, and Washington). Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

Herbel, C. H., P. L. Sims, W. A. Laycock, R. J. Lorenz, R. A. Evans, K. G. Renard, SEA-AR Rangeland Scientists in the 17 Western States, R. F Barnes, and G. E. Carlson. 1980. Range research, an assessment of current problems and a strategy for the future: A summary of range research by SEA-AR in the 17 western states. Agricultural Research, Science and Education Administration, U. S. Department of Agriculture. 18 pages.

Laycock, W. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Central Great Plains. 1980. SEA-AR range research in the Central Great Plains (Colorado, Kansas, Nebraska, and Wyoming). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Lorenz, R. J., J. R. Wight, R. J. Kartchner, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Northern Great Plains. 1980. SEA-AR range research in the Northern Great Plains (Montana, North Dakota, and South Dakota). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Renard, K. G., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southwest. 1980. SEA-AR range research in the Southwest (Arizona, California, and New Mexico). Agricultural Research, Science and Education Administration, U. S. Deparment of Agriculture.

Sims, P. L., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains. 1980. SEA-AR range research in the Southern Great Plains (Oklahoma and Texas). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

[illegible] Rangeland Scientists [illegible]
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Oregon, Utah, and Washin[illegible]
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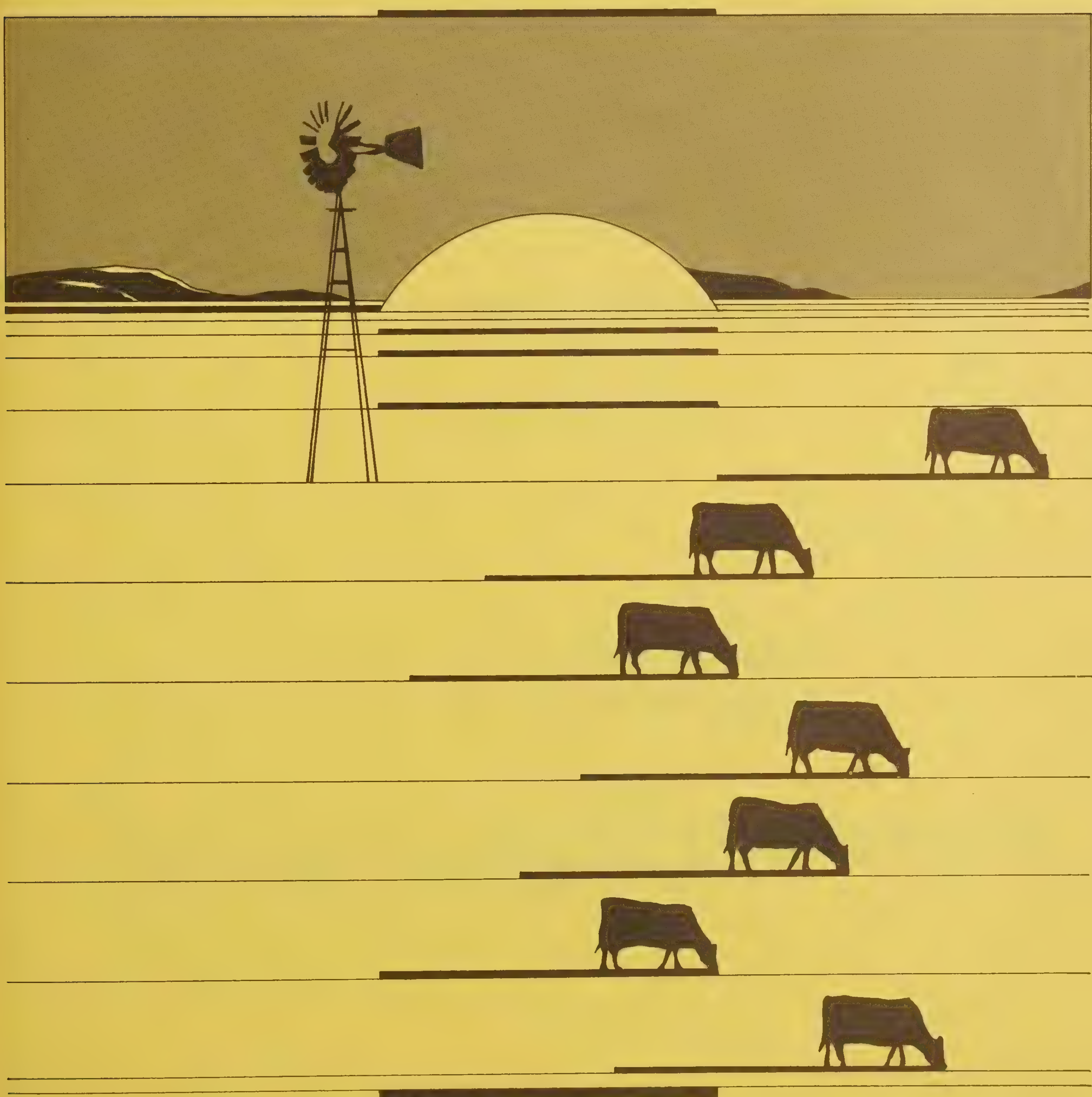
[illegible] Agriculture.

SEA-AR Range Research Assessment

Northwest



United States Department of Agriculture
Science and Education Administration
Agricultural Research

RANGE RESEARCH

An Assessment of Current Problems

and

A Strategy for the Future

GREAT BASIN AND NORTHWEST SUBREGION

Nevada, Utah, Idaho, Oregon, Washington

Prepared by

Raymond A. Evans, Carlton H. Herbel, and SEA-AR Forage and Range Scientists in the Great Basin and Northwest Subregion, and Robert F Barnes and Gerald E. Carlson, National Program Staff Scientists.

CONTENTS

SEA-AR Range Research

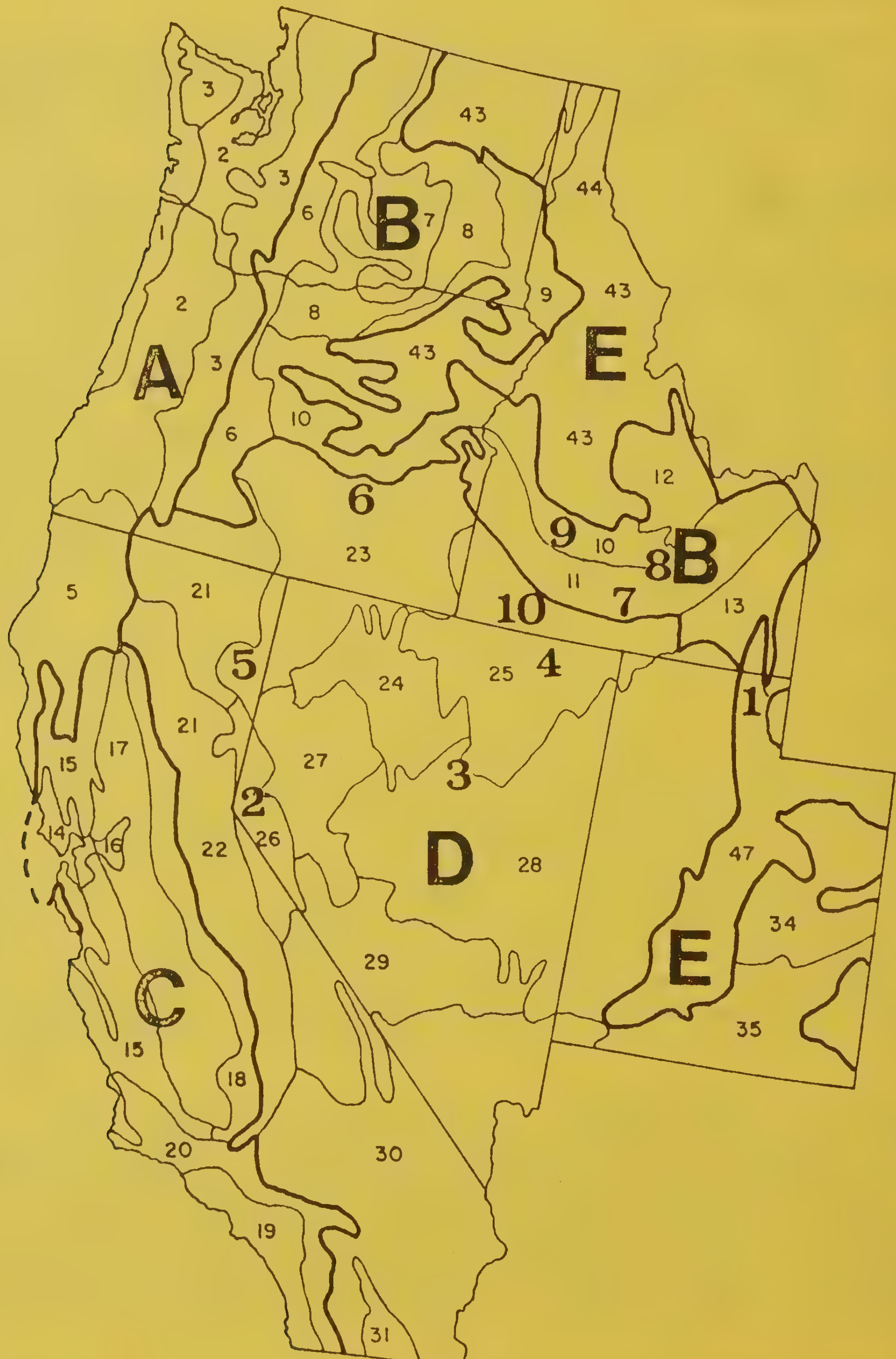
Great Basin and Northwest Subregion
(Nevada, Utah, Idaho, Oregon, Washington)

I. The Situation

The Great Basin and Northwest Subregion (GBN Subregion) is generally represented by the Intermountain Sagebrush Ecoregion, which encompasses most of Nevada and part of Utah, Idaho, Oregon, Washington, and California. Primary subdivisions of this ecoregion (Bailey, 1978) are: Sagebrush-Wheatgrass (44.1%), Lahontan Saltbush-Greasewood (16.4%), Great Basin Sagebrush (23.1%), Bonneville Saltbush-Greasewood (10.9%), and Ponderosa Shrub Forest (5.5%) (see Appendix A-1). According to Austin's regions and land resource areas (Austin, 1972), most of the rangeland area of the GBN Sub Region is in the Western Range and Irrigated Region. The total land area of this region is 280,187,000 acres of which 84.4%, or 236,491,000 acres, is forest and range. This forest-range area supports 23,865,732 animal unit months (AUM's), which represents 58.1% of the total livestock production in the region. Appendix A presents rangeland types, areas, conditions, stocking rates, and productions in the GBN Subregion. Rangelands of this region are characterized by a brush or tree overstory with an understory of grass and other herbaceous species. In much of the area, an overabundance of brush, weedy trees (Pinon, Juniper) and herbaceous weeds drastically reduces forage production. Potential versus present stocking on these range ecosystems is 328%, so, with range improvement, three times as many livestock could be supported by these rangelands. For example, according to the FRES report (U.S. Forest Service, 1972), 4.6% of sagebrush rangelands are in good condition, 51.5% in fair condition, and 43.8% in poor condition (Appendix A). These estimates for condition classes are for the country as a whole and, when applied on a state-to-state basis, can be very misleading. In Nevada, a detailed study was made of the Humboldt River Basin in 1966. This area is representative of the rangelands of the northern part of the state. Results of this study indicated that only 1% of the sagebrush-grass rangelands are in a fairly high production class, 11% in the medium class, and 88% are in the low class (Appendix A-2). When this rangeland has been improved through range seeding, 78% is in fairly high production class. A large portion of the rangelands in the GBN Subregion are federally-owned and administered by the Bureau of Land Management and the Forest Service. These rangelands are managed as a multiple-use resource where wildlife, watershed, and recreational values must be considered in addition to livestock production.

Based on 1977 Agricultural Statistics, there are over 5 1/2 million livestock in the GBN Subregion. Cattle number 4,014,000 (72% of total), and sheep 1,544,000 (28%). Detailed information is shown in Appendix B for class of livestock, numbers, and animal units (AU's) in the GBN Subregion. Estimates of wildlife numbers by state in the GBN Subregion are given in Appendix C. Land Resource Regions and Major Land Resource Areas of the GBN Subregion are shown on page 2. Numbers designate locations of SEA-AR range activities. See following pages for legend and names of locations.

Land Resource Regions and Major Land Resource Areas of the Northwest Region. Numbers designate locations of SEA-AR range activities. See following pages for legend and names of locations.



Legend for Land Resource Regions and Major Land Resource Areas of the Northwest Region (not including California).

A. Northwestern Forest, Forage, and Specialty Crop Region:

2. Williamette and Puget Sound Valleys
3. Olympic and Cascade Mountains (Western Slope)
5. Siskiyou - Trinity Area

B. Northwestern Wheat and Range Region:

6. Cascade Mountains (Eastern Slope)
7. Columbian Basin
8. Columbian Plateau
9. Palouse and Nez Perce Prairies
10. Upper Snake River Lava Plains and Hills
11. Snake River Plains
12. Lost River Valleys and Mountains

D. Western Range and Irrigated Region:

21. Klamath and Shasta Valleys and Basins
23. Malheur High Plateau
24. Humboldt Area
25. Owyhee High Plateau
26. Carson Basin and Mountains
27. Fallon-Lovelock Area
28. Great Salt Lake Area
29. Southern Nevada Basin and Range
30. Sonoran Basin and Range
34. Central Desertic Basins, Mountains, and Plateaus.

E. Rocky Mountain Range and Forest Region:

43. Northern Rocky Mountains
44. Northern Rocky Mountain Valleys
47. Wasatch and Vinata Mountains
48. Southern Rocky Mountains

Locations of SEA-AR Range Activities

1. Logan, UT (both Forage Improvement and Poisonous Plant Projects are area-wide).
2. Reno, NV
3. Gund Ranch (Reno, NV)
4. Saval Ranch (Reno, NV)
5. Myers Ranch (Reno, NV)
6. Burns, OR (Squaw Butte Field Station)
7. Kimberly, ID (Animal Nutrition Research is area-wide)
8. Dubois, ID
9. Boise, ID (headquarters and Boise Front locations)
10. Reynolds Creek (Boise, ID)

II. Problems and Trends

The rangelands are in an arid to semiarid region where lack of available moisture limits growth of vegetation. The imbalance between favorable temperatures for growth and occurrence of precipitation (mostly winter precipitation) accentuates the overall ineffectiveness of rain and snow. Year-to-year variation in precipitation is great and has a marked effect on growth of vegetation and forage yield. The general lack of moisture and the annual and seasonal variability are serious deterrents to establishment of plants and make mandatory the use of the most effective weed control and seeding technologies for successful seeding of rangelands.

In the saltbrush-greasewood ecosystems, soil salinity is a major problem, especially in relation to revegetation efforts. In the other ecosystems, general aridity and competition from brush and weeds are problems.

Most of the rangelands of this ecoregion have been degraded by overgrazing and other mismanagement to a low successional level so that domination by brush, trees, and weeds occur on millions of acres. For example, in the Humboldt River Basin of Nevada, only 1% of the Big Sagebrush-grass areas are in high condition, while 88% are in low condition (Appendix A-2).

The present environmental constraints, especially those imposed on federal lands, tend to restrict the development and use of range improvement practices that would encourage increased forage production and the betterment of rangeland communities.

Two of the most recent positive actions by the federal government for improvement of the western range resource for all uses are acts passed by Congress. The first is the Federal Land Policy and Management Act passed by the 94th Congress in 1977 which, in part, establishes a policy for funding of range improvements on federal rangelands. According to this Act, 50% of the grazing fees collected will be used for on-the-ground range rehabilitation, protection, and improvements. One-half of these funds will be used for range improvement in the district where the grazing fees were collected and the other half used in areas as directed by the BLM. In this Act, range improvement includes all forms of rangeland betterment such as: seeding and reseeding, fence construction, weed control, water development, and fish and wildlife enhancement.

The second is the Public Rangeland Improvement Act of 1978 passed by the 95th Congress on October 11, 1978. Many opportunities and responsibilities fall under the Public Rangelands Act. It serves as an additional affirmation of national commitment to the principles of multiple use and the inclusion of the public rangelands in that concept. It further harmonizes grazing management with multiple use management objectives. If funding authorized by the Act is forthcoming, and if BLM meets the challenge of the Act, BLM will be placed in a stronger position to pursue constructive land management policies and exemplary scientific techniques. By this Act, the Congress establishes and reaffirms a national policy and commitment to manage, maintain, and improve the condition of public rangelands so that they become as productive as feasible for all rangeland values. The term "range improvement" in this Act means any activity or program on or relating to rangelands

which is designed to improve production of forage, change vegetative composition, control patterns of use, provide water, stabilize soil and water conditions, and provide habitat for livestock and wildlife.

While both of these Acts provide for range improvement on federal lands, these practices must be part of Allotment Management Plans (AMP's) in specific areas and be included in Environmental Statements (ES's) to satisfy prevailing court orders (NRDC vs BLM).

The Bureau of Land Management is in the process of writing Environmental Statements for individual districts throughout the West (150 million acres). If range improvement-grazing management technologies developed by SEA-AR are to be included in the ES's, an effective technology transfer must be developed now.

An interdisciplinary research approach for developing range improvement and grazing management technology can best investigate problems of multiple use on rangelands. By this approach, interactions of range improvement and grazing management not only can be studied, but they can be studied in relation to the varied uses and values of these lands. The latter relationships are most important in order to address the intent of the Public Rangeland Improvement Act of 1978 as well as other legislation, court orders, and policies of the BLM and Forest Service.

III. Researchable Problems and Goals

Research on range improvement (brush and weed control, seeding of improved forage and browse species, and grazing management) is of highest priority. Many methods of revegetation have been developed in the past, but emphasis now should be on developing systems approach technology to control brush and herbaceous weeds while creating a favorable seedbed for seeding forage and browse species in combined operations. Development of improved forage plants is a vital part of successful revegetation efforts. An adapted legume for seeding with grasses in this ecoregion is of primary importance; possibly an improved alfalfa variety for the more mesic areas and a lupine variety for the more arid sites. Better adapted and higher yielding grasses are also needed. At present, crested wheatgrass is the only species that can be successfully used on large areas of these rangelands. Planting of desirable shrub species, especially in mixtures with grasses and other forage plants, constitutes a promising approach. Breeding grasses and other range plants for resistance to moisture stress, salinity, and insect pests, and breeding legumes for more efficient nitrogen-fixation under rangeland conditions are other viable possibilities.

Alternative methods to chemical brush and weed control should be developed. In the future, use of herbicides might be curtailed or restricted, as alternatives, the use of fire or biological agents for brush control should be thoroughly researched.

Development and evaluation of grazing management treatments are needed to meet livestock and multiple use objectives and to combine the most effective revegetation and management techniques into systems to optimize red meat

production and multiple use values.

Basic ecological research should be conducted on rangelands to study the effects of revegetation, pests, manipulative treatments, and grazing systems on the entire ecosystem. Effects of revegetation and grazing practices should be assessed in terms of forage production, community stability, watershed values, and wildlife.

An interdisciplinary team approach is necessary to evaluate the effects of range improvement and grazing management in terms of the many values and uses of rangeland. To comprehensively study these effects, a team should ideally be composed of range scientists, plant breeders, soil scientists, animal scientists, watershed specialists, wildlife specialists, and economists. A necessary setting for this type of research is a ranch operation where close controls can be exercised over range improvement treatments and livestock grazing. A mix of private and public lands is most representative of a range operation in this region. Close cooperative ties with the Bureau of Land Management and Forest Service are highly desirable for efficient and effective technology transfer from research to action agencies.

A. Research Needs

Each scientist working in the GBN Subregion was asked to rate research needs in 12 research categories. Ratings of needs were designated by the following:

High	-5
High medium	-4
Medium	-3
Medium low	-2
Low	-1

The overall average rating of each of the 12 categories are shown below. The categories are arranged in descending order of ratings.

		Rating
XI	Basic research	4.2
VIII	Effects of practices III-VII	4.0
III	Revegetation	3.9
II	Improved plants	3.8
VII	Grazing systems	3.7
X	Wildlife	3.4
VI	Complementary pastures	3.3
XII	Models	3.3
IX	Livestock	3.1
I	Inventory and classification	3.1
IV	Ecology, damage, and control of pests	3.0
V	Other manipulative treatments	2.9

The following more specific research needs were identified:

A. Collecting of germplasm; breeding of plants for resistance to stress, increased photosynthetic efficiency, improved

forage quality and quantity, and increased water efficiency; and breeding of native forage species for improved seed production.

B. Study the effect of revegetation, pests, manipulative treatments, and grazing systems on range ecology, on water quality and quantity, moisture conservation, and animal performance and behavior.

C. Study germination, seedling establishment, and grazing adaptability of seeded species; study the physiology of range plants; and conduct basic research on water use by plants and nitrogen fixation.

D. Modeling for detection of range management influences on rangeland hydrology and evaluation of the effects of rangeland management decisions; and modeling to ascertain research needs and to assist in managing all resources on rangelands.

E. Study the ecology, damage, and control of weeds and insects.

F. Study livestock performance and distribution; plant-animal interactions; grazing systems; and wildlife-livestock interactions.

G. Inventory and classification of climate, site potential, and assessment of forage crops and inventory of animal populations and their movements.

IV. <u>Current Research Effort</u>

A. Research Locations

1. <u>Logan, UT - (Forage Improvement - Plant Breeding)</u>

a. <u>Mission</u>. To provide a broad spectrum of improved forage grasses, legumes, and forbs for upgrading rangeland of the Intermountain Region for conservation, reclamation, recreation, and production purposes. A team of five scientists--cytogeneticist, physiologist, grass breeder, legume breeder, range scientist--is working on this mission.

<u>General Service Area</u>:

Intermountain Range - Forest Zone

b. <u>Land Resource Regions and Areas (Austin, 1972)</u>:

<u>Northwestern Wheat and Range Region (B)</u>

Upper Snake River Lava Plains and Hills (10)
Snake River Plains (11)
Lost River Valleys and Mountains (12)
Eastern Idaho Plateaus (13)

Western Range and Irrigated Region (D)

Owyhee High Plateau (25)
Great Salt Lake Area (28)
Central Desertic Basins, Mountains, and Plateaus (34)
Colorado and Green River Plateaus (35)

Rocky Mountains Range and Forest Region (E)

Northern Rocky Mountains (43)
Wasatch and Vinata Mountains (47)

Western Great Plains Range and Irrigated Region (G)

Northern Rolling High Plains (58)

Elevation: 4,500 - 9,000 feet

c. Climate (average):

Precipitation: 10-45 inches annual (summer drought mid June-August)
Temperature: 25-50° F
Frost-Free Period: 60-150 days

Soils (suborder: Argids, Orthids, Orthents, Borolls, Ustolls, Aridisols (gray wooded, lithosol, brunizem, brown, and sierozems)

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)

e. Ecosystem (Forest Service, 1972):

Sagebrush
- 32 - Great Basin Sagebrush
- 49 - Sagebrush Steppe

Desert Shrub
- 34 - Saltbush-greasewood
- 33 - Blackbrush

Chaparral-Mountain Shrub
- 31 - Mountain Mahogany-Oak Scrub

Pinyon-Juniper
- 21 - Pinyon-Juniper Woodland

Mountain Grassland
- 43 - Fescue-Wheatgrass
- 56 - Foothills Prairie

Mountain Meadow

Lodgepole Pine
8 - Lodgepole Pine - Subalpine Forest

Plains Grasslands
59 - Wheatgrass-Needlegrass

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964) (Listed under individual locations):

PRINCIPAL STUDY SITES:

Headquarters - Logan, Utah and Vicinity

b. Land Resource Region and Area (Austin, 1972):

Rocky Mountain Range and Forest Region (E)
Wasatach and Vinata Mountains (irrigated and dryland)(47)
Elevation: 4,400 - 4,600 feet

c. Climate (Average):

Precipitation: 16-17 inches annual, winter-spring, summer drought
Temperature: 46-49° F
Frost-Free period: 110-120 days
Soil: Aridisols (brown - sierozem)

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Bonneville Saltbush - Greasewood (3134)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silk lupine
Oryzopsis hymenoides, Indian ricegrass

Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Sitanion spp., squirreltail

Blue Creek Experimental Farm, Utah

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)
Great Salt Lake Area (28)
Elevation: 5,000 feet

c. Climate (Average):

Precipitation: 14 inches annual, summer drought
Temperature: 46° F
Frost-free period: 100 days
Soil: Aridisols (sierozem)

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1962):

Sagebrush Steppe

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silk lupine
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Sitanion spp., squirreltail

Curlew Valley, Utah - Idaho

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)
Great Salt Lake Area (28)
Elevation: 4,700 feet

c. Climate (Average)

Precipitation: 10 inches
Temperature: 46° F
Frost-Free period 110 days
Soils: Aridisols (desert-sierozem)

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Great Basin Sagebrush

Artemisia tridentata, big sagebrush

Others:

Agropyron smithii, western wheatgrass
Artemisia nova, black sagebrush
Atriplex confertifolia, shadscale
Chrysothamnus spp., rabbitbrush
Ephedra spp., Mormon tea

Nephi Experimental Farm, Utah

b. Land Resource Region and Area (Austin, 1972):

Rocky Mountain Range and Forest Region (E)
Wasatch and Vinata Mountains (47)
Elevation: 5,100 feet

c. Climate (Average):

Precipitation: 13 inches
Temperature: 50° F
Frost-Free period: 120 days
Soil: Aridisols (desert-sierozem)

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Great Basin Sagebrush (3133)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Great Basin Sagebrush

Artemisia tridentata, big sagebrush

Others:

Agropyron smithii, western wheatgrass
Artemisia nova, black sagebrush
Atriplex confertifolia, shadscale
Chrysothamnus spp., rabbitbrush
Ephedra spp., Mormon tea

Canyon Mountain Validation Area (Delta-Fillmore, Utah)

b. Land Resource Region and Area (Austin, 1972):

Rocky Mountain Range and Forest Region (E)
Wasatch and Vinata Mountains (47)
Elevation: 5,200 - 8,000 feet

c. Climate (Average):

Precipitation: 13 inches (Scipio)
Temperature· 48° F (Scipio)
Frost-Free period: 110 days (Scipio)
Soil: Aridisols, Orthent (Sierozem-Azonal)

d. Ecoregion (Bailey, 1978):

Shortgrass Prairie (3110)
Wheatgrass-Needlegrass (M3112)

e. Ecosystem (Forest Service, 1972):

Pinyon-Juniper

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Great Basin Sagebrush

Artemisia tridentata, big sagebrush

Others:

Agropyron smithii, western wheatgrass
Artermsia nova, black sagebrush
Atriplex confertifolia, shadscale
Chrysothamnus spp., rabbitbrush
Ephedra spp., Mormon tea

Mountain Mahogany Oak Scrub

Cercocarpus ledifolius, mountain mahogany
Quercus gambelii, gambel oak

Others:

Acer grandidentatum, bigtooth mahogany
Amelanchier utahensis, Utah serviceberry
Arctostaphylos spp., manzanita
Ceanothus veluthinus, snowbrush
Cowania mexicana, cliffrose
Fallugia paradoxa, Apache plume
Pachystima myrsinites, myrtle
Physocarpus malvaceus, mallow ninebark
Purshia tridentata, antelope bitterbrush
Quercus havardii, oak species
Q. turbinella, shrub live oak
Q. undulata, waveyleaf oak
Rhus trilobata, skunk bush sumac
Symphoricarpos spp., snowberry

Juniper-Pinyon Woodland

Juniperus monosperma, oneseed juniper
Juniperus osteosperma, Utah juniper
Pinus edulis, pinyon pine
Pinus monophylla, oneleaf pine

Others:

Agropyron smithii, western wheatgrass
Artemisia tridentata, big sagebrush
Bouteloua curtipendula, side-oats grama
B. gracilis, blue grama
Ceanothus spp., snowbrush
Cercocarpus spp., mountain mahogany
Chrysothamnus spp., rabbitbrush
Cowania mexicana, cliffrose
Fallugia paradoxa, Apache plume
Juniperus deppeana, juniper species
J. occidentalis, western juniper
Oryzopsis hymenoides, Indian ricegrass
Purshia tridentata, antelope bitterbrush
Quercus emoryi, oak species
Q. gambelii, gambel oak
Q. grisea, gray oak
Q. undulata, wavyleaf oak
Sporobolus cryptandrus, sand dropseed

Cokeville, Wyoming

b. Land Resource Region and Area (Austin, 1972):

Rocky Mountain Range and Forest Region (E)
Northern Rocky Mountain(43)
Elevation: 6,600 feet

c. Climate (Average):

Precipitation: 14 inches
Temperature: 39° F
Frost-Free period: 90 days
Soils: Aridisols (brown-sierozem)

d. Ecoregion (Bailey, 1978):

Steppe (3100)
Sagebrush-Wheatgrass (A3142)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species(Kuchler, 1964):

Sagebrush Steppe

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silk lupine
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Sitanion spp., squirreltail

Decker, Montana

b. Land Resource Region and Area (Austin, 1972):

Western Great Plains Range and Irrigated Region (G)
Northern Rolling High Plains(58)
Elevation: 3,500 feet

c. Climate (Average):

Precipitation: 15 inches
Temperature: 48° F
Frost-Free period: 105 days
Soils: Aridisols (brown)

d. Ecoregion (Bailey, 1978):

Steppe (3100)
Grama-Needlegrass-Wheatgrass (3111)

e. Ecosystem (Forest Service, 1972):

Plain grasslands

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Wheatgrass-needlegrass

Agropyron smithii, western wheatgrass
Artemisia tridentata, big sagebrush
Poa arida, plains bluegrass
Stipa comata, needle-and-thread grass

Others:

Agropyron spicatum, bluebunch wheatgrass
Artemisia cana, silver sagebrush
A. frigida, fringed sagebrush
Atriplex canescens, four-wing saltbush
A. confertifolia, shadscale
Carex filifolia, sedge
Ceratoides lanata. winterfat
Koeleria cristata, Junegrass
Sarcobatus vermiculatus, greasewood

g. Objectives:

1. To collect forage germplasm from worldwide sources and to describe its reproductive and cytogenetic characteristics. To synthesize new species through wide hybridization.

2. To develop techniques for screening plants for tolerance to drought, cold, and salinity. To determine the basic physiological mechanisms of stress tolerance.

3. To develop superior varieties of range grasses. To determine the causes of sterility in interspecific hybrids.

4. To develop superior varieties of range legumes and forbs. To determine the nitrogen-fixing characteristics of range legumes.

5. To evaluate the improved plant materials arising from the above breeding programs. To develop improved methods of establishing plants on range sites.

h. Status:

1. The cytogenetic and germplasm collecting efforts have been underway at Logan for 20 years. The world's most diverse collection of perennial range grasses (*Agropyron Hordeum Elymus Sitanion*) has been assembled at Logan. Reproductive and cytogenetic characteristics have been determined for most of the species. More than 250 interspecific and intergeneric hybrid combinations have been produced. More than 50 new species have been synthesized from the hybrid populations. Most of the new species are inferior to naturally occurring species; however, a few appear to be superior to existing species. The most promising hybrid populations have been turned over to the team's grass breeder for further improvement.

2. The physiological work has been in progress since 1976. Laboratory, greenhouse, and growth chamber techniques have been developed for screening breeding populations of grasses and legumes for drought tolerance. The plant breeders are currently using these screening techniques. The effectiveness of laboratory screening procedures in improving field performance is in the process of being evaluated.

3. The grass breeding program was established in 1974. Major breeding efforts are concentrated on crested wheatgrass, Russian wildrye, and interspecific hybrids. Two germplasm pools of the *Agropyron repens* x *A. spicatum* hybrid were recently released. Sterility problems are being studied in several other hybrids. Experimental strains of crested wheatgrass and Russian wildrye have been developed for testing. Recent introductions of Russian wildrye have demonstrated particular promise.

4. The range legume breeding effort was started in 1977. The entire USDA alfalfa collection is being screened in the laboratory and on a dryland site for seed production, root proliferation, forage yield, and bloating qualities. Smaller programs are being conducted with species of *Astragalus*, *Hedysarum*, *Pulinus*, *Sanguisorba*, and *Vicia*. The nitrogen fixing capabilities of legumes

on dryland sites are being studied in collaboration with the physiologist.

5. The range scientist was added to the forage improvement team in 1978. Plant materials derived from the breeding programs are in early stages of evaluation on varied range sites in the intermountain region.

i. Plans:

1. Obtain additional germplasm from arid sites in the USSR and western China. Prepare a taxonomic revision based on phylogenetic relationships. Produce additional new species through wide hybridization.

2. Evaluate the effectiveness of current screening techniques for drought, cold, and salinity, and improve those techniques. Determine the basic mechanisms of stress physiology.

3. Release varieties of crested wheatgrass and Russian wildrye, then concentrate efforts on breeding native species and wide hybrids derived from the cytogenetic program.

4. Release improved varieties of alfalfa adapted to rangeland. Emphasize studies on the nitrogen fixing characteristics of legumes under range conditions.

5. Develop an extensive cooperative network with other organizations and individuals to evaluate improved plant materials on typical range sites.

6. Evaluate the effects of environmental stress on nitrogen fixation in promising native and introduced legumes.

j. Opportunities and Needs:

Many opportunities exist in plant exploration, physiological research, and other aspects of collecting and breeding range plants. Some of the needs are: (i) better accessibility of germplasm from the USSR and China, and (ii) better understanding of the physiological basis of stress tolerance. Some other needs are to surmount the following obstacles: (i) plant breeders are spread too thinly over too many species, (ii) insufficient greenhouse space, (iii) inadequate means of maintaining, increasing, and distributing improved varieties, and (iv) expense of evaluating plant materials with grazing livestock. Insufficient support of technician and labor level is the most limiting need.

2. Logan, UT - (Poisonous Plants - Control, Ecology, and Effects on Animals):

a. Mission. Prevent livestock poisoning by plants.

General Service Area. That of the various ecoregions of the United States.

Headquarters - Logan, Utah and Vicinity

b. Land Resource Region and Area (Austin, 1972):

Rocky Mountain Range and Forest Region (E)
  Wasatch and Vinata Mountains (irrigated and dryland) (47)
Elevation: 4,400 - 4,600 feet

c. Climate (Average):

Precipitation: 16-17 inches annual, winter-spring, summer drought
Temperature: 46-49° F
Frost-Free period: 110-120 days
Soil: Aridisols (brown - sierozem)

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Bonneville Saltbush-Greasewood (3134)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silk lupine
Oryzopsis hymenoides, Indian ricegrass
Poa sanbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Sitanion spp., squirreltail

g. Objective: The toxins and teratogens, toxic effects, mode of action, and conditions of poisoning are being investigated in locoweeds, larkspur, conium, ponderosa pine, veratrum, sneezeweed, tetradymia, nicotiana, lupine, and others. Results of these investigations will be used to develop methods of management and other measures for the prevention of livestock poisoning by plants.

h. Status:

Poisonous plants are one of the principal causes of economic loss to the livestock industry of the world. The principal causes of these losses are due to deaths, chronic illness and debilitation, decreased weight gains, abortions, birth defects, and photosensitization.

In addition to these more obvious losses we must include increased costs associated with managing rangeland pasture infested with poisonous plants. Some of the less obvious but important costs include fencing, loss of forage, increased labor costs in herding livestock, increased veterinary costs, and in some cases, supplemental feeding and altered grazing programs. It is estimated that these direct and indirect losses total between \$200- and \$300-million annually.

Poisonous plants are an important part of almost all ecosystems where livestock are grazed. Poisonous plants should be taken into consideration in devising grazing programs and other range improvement programs. Failure to do so can produce adverse effects.

Successful management programs have been developed at the Poisonous Plant Research Laboratory for the prevention of crooked calf disease (lupine), malformed lamb disease (veratrum), halogeton poisoning, and others. The Poisonous Plant Research Laboratory is the only laboratory in the United States devoted exclusively to the study of livestock poisoning by plants. Only a limited amount of poisonous plant research is being conducted by State Agricultural Experiment Stations.

i. Plans: It is planned to continue to investigate the toxins and teratogens, toxic effects, mode of action, and conditions of intoxication of the principal livestock poisoning plants of the United States. Data developed will be used to formulate management strategies for the prevention of livestock poisoning by plants. The plants studied will be those listed under Objectives, plus others of primary importance.

j. Opportunities and Needs: The most pressing need at the

Poisonous Plant Research Laboratory is for increased staffing, which would include: a Research Veterinary Pathologist, a Research Range Scientist, and a Research Chemist.

3. Reno, NV (Range Management - Brush and Weed Control, Reseeding, and Grazing Management):

   a. Mission: To develop revegetation and grazing management techniques for improvement of degraded sites for increased forage and livestock production consistent with the conservation and enhancement of other multiple-use values of rangelands.

Headquarters - Reno, NV

   b. Land Resource Region and Area (Austin, 1972):

      Western Range and Irrigated Region (D)
        Carson Basin and Mountains (26)
      Land Use: 90% in ranching
      Elevation: 4,000-6,500 feet

   c. Climate (Average):

      Precipitation: 5-15 inches winter, spring, summer drought
      Temperature: 40-52° F
      Frost-Free period: 60-150 days
      Soils: Humic Gley, alluvial, desert soils, sierozems, brown soils, and solonchak

   d. Ecoregion (Bailey, 1978):

      Intermountain Sagebrush (3130)
      Sagebrush-Wheatgrass (3131)

   e. Ecosystem (Forest Service, 1972):

      Sagebrush

   f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

      Sagebrush Steppe:

         Agropyron spicatum, bluebunch wheatgrass
         Artemisia tridentata, big sagebrush

      Others:

         Artemisia arbuscula, low sagebrush
         Balsamorrhiza sagittata, arrowleaf balsamroot
         Festuca idahoensis, Idaho fescue

Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Chrysothamnus spp., rabbitbrush

Gund Ranch - (Reno, NV)

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (C)
Great Salt Lake Area (28)
Land Use: Livestock production is principal agricultural activity.
Elevation: 4,000-6,500 feet in the basins and 6,500-11,000 feet in the mountains.

c. Climate (Average):

Precipitation: 5-20 inches, midsummer to early autumn is driest period.
Temperature: 45-55° F
Frost-Free period: 60-160 days
Soils: Alluvial, desert soils, sierozems, calcisols, solunetz, solonchak, and lithosols.

d. Ecoregions (Bailey, 1978):

Intermountain Sagebrush (3130)
Great Basin Sagebrush (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Great Basin Sagebrush

Artemesia tridentata, big sagebrush

Others:

Agropyron smithii, western wheatgrass
Artemisia nova, black sagebrush
Atriplex confertifolia, shadscale
Chrysothamnus spp., rabbitbrush
Ephedra spp., Mormon tea
Poa sandbergii, Sandberg bluegrass

Saval Ranch - (Reno, NV)

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)
Owyhee High Plateau (25)
Land Use: Range livestock production
Elevation: 4,500-7,500 feet in basins and plains and up to 11,000 feet in the mountains.

c. Climate (Average):

Precipitation: 8-16 inches evenly distributed, but driest midsummer to early autumn.
Temperature: 43-47° F
Frost-free period: 90-140 days
Soils: Brown soils, chestnut soils, lithosols, chernozems, planosols, sierozems, alluvial soils, humic gleys, and solonetz.

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Sagebrush-Wheatgrass (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Chrysothamnus spp., rabbitbrush

Myers Ranch (NE California) - (Reno, NV)

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)

Klamath and Shasta Valleys and Basins (21)
Land Use: Livestock grazing is principal agricultural activity.
Elevation: 2,500-4,500 feet - Some mountain peaks - 6,000+

c. Climate (Average):

Precipitation: 12-20 inches, summers dry
Temperature: 45-52° F
Frost-free period: 70-140 days
Soils: chestnut soils, grumusols, alluvial soils, and brown forest soils.

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Ponderosa Shrub Forest (3135)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Juniperus occidentalis, Western Juniper
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Chrysothamnus spp., rabbitbrush

g. Objectives:

1. Evaluate site factors and species characteristics that are desirable or undesirable for range improvement.

2. Determine the best methods of weed control, site preparation, species, and methods of seeding for revegetation and the impacts on multiple use.

3. Evaluate the effectiveness of grazing management treatments to meet livestock and multiple-use objectives.

4. Combine the most effective revegetation and management techniques into a system to optimize red meat production and multiple-use values.

h. Status:

1. Some site and species characteristics in relation to revegetation techniques are well known. Work is in progress to gain information on site and species characteristics for additional ecosystems and for additional sites within ecosystems.

2. Several effective brush/weed control-revegetation methods have been developed and evaluated under field conditions. Work is now in progress to develop weed control-revegetation techniques for additional ecosystems and additional sites within ecosystems.

3. Evaluation of grazing management systems has progressed through one 3-year cycle.

4. Research is in progress on revegetation techniques and grazing management systems and their effects on the grazing resource, environmental impacts, and multiple-use values.

i. Plans:

Develop cost-effective environmentally acceptable techniques to revegetate the more difficult vegetation types in the sagebrush ecosystems. Determine the chemical and mechanical techniques and species for interseeding forbs and shrubs into various vegetative mono-types. Evaluate new grazing treatments keyed to enhancement of wildlife habitat as it affects soils, plants, livestock, and wildlife. Determine the proper integration of intensely managed native and manipulated range to develop and maintain stable, high-producing rangelands for livestock production compatible with other resource values.

The Gund Research and Demonstration Ranch is important to SEA-AR range research, because it provides needed degraded sagebrush and other representative rangelands for the establishment of large-scale trials for range improvement-grazing management evaluation under the Pilot Testing Program and within the Cooperative SEA-AR/University of Nevada Range-Livestock-Watershed-Wildlife Program.

The Saval Ranch Research and Evaluation Areas in Nevada was established by the BLM-USDI, SEA-AR-USDA, FS-USDA, SCS-USDA, and the Saval Ranch. The overall objective of this program is to conduct research on and evaluate the overall

effectiveness of rangeland management (grazing management and range improvements) on livestock production, vegetation, fish and wildlife and their habitats, watershed, water quality, socio-economic factors, and other resource values.

This large-scale research program, together with the Gund Ranch Research Program, will evaluate by cooperative research, range improvement-grazing management programs on private and federal lands. As a consequence of involvement of federal land agencies, technology transfer can be accomplished by SEA-AR to the BLM and FS as the information is being developed.

j. Opportunities and Needs:

The three primary work sites (Gund Ranch, Saval Ranch, and Myers Ranch) provide excellent research areas to evaluate, on a large scale, revegetation techniques and grazing management systems from the interdisciplinary aspects of vegetation response, cattle production, soils and watershed, and wildlife management.

Additional SEA-AR professional and support personnel are needed, especially in soils and watershed, to conduct this comprehensive study.

An opportunity exists for closer coordination between revegetation research in Nevada and the Forage Improvement Research Team in Logan, Utah. Of high priority is the need for a Range Agronomist to evaluate plant material developed in Logan in the Nevada Range Research Program. A Range Agronomist could also test native plant material and integrate the seed germination research from Reno with plant selection and breeding efforts in Logan.

Close cooperation and coordination have developed and are developing between the SEA-AR research teams in Reno and Boise in the areas of range watershed and range modeling. Opportunities for strengthening these research thrusts also exist by adding scientists and support personnel.

4. Burns, OR (Range Management)

a. Mission. To increase the efficiency of red meat (wild and domestic) production from our rangelands and to improve the environment for all uses of the cold desert biome.

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)
Malheur High Plateau (23)

Land Use: 95% in ranching
Elevation: 4,500-7,000 feet

c. Climate (Average):

Precipitation: 8-14 inches, winter maximum, summer drought
Temperature: 41-50° F
Frost-free period: 60-140 days
Soil: Sierozems, brown soils, grumusols

d. Ecoregion (Forest Service, 1972):

Intermountain Sagebrush (3130)
Sagebrush-Wheatgrass (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Chrysothamnus spp., rabbitbrush

g. Objectives:

1. Evaluate the potential of specific plants for revegetation opportunities (currently *Kochia p*.).
2. Research the effectiveness and feasibility of precipitation catchments for large animal water and for large animal grazing control.
3. Define the opportunities and the limitations for prescribed burning of the sagebrush ranges.
4. Quantitize the specific forage pressure by large animal species.

5. Examine soil-plant constituent relations within the big sagebrush subspecies.

6. Continue to gather data for more complete understanding of climate-plant relations.

h. Status:

Primary determinants of herbaceous yield have been modeled for summer dry portions of the sagebrush-bunchgrass range. Predictive forecasts are operational. Productivity and chemical attributes have been described for two forms of *Kochia p.* and its response to 2,4-D and fire have been examined. In cooperation with the University of Nebraska, seed viability is being conducted. Design, efficiency, and longevity of precipitation-catchments are now proceeding into the eighth year. Larger, 5,000 gal systems using bottomless tank construction and a layered bentonite seal were started in 1978.

Food habits of ungulates grazing two different eastern Oregon ranges have been described. Burning impacts on individual species in two years and their recovery response have been completed.

There was Congressional action to retain current SEA-AR positions at the Squaw Butte Experiment Station, Burns, Oregon, and to provide additional scientific staff. This integrated Oregon State University--SEA-AR meadow-rangebeef research complex is one of the few research locations in the United States where complete control of land, cattle, and facilities permit studies restricted only by imagination and funding. The additional support money will permit broader and deeper studies of the soil-vegetation-animal response interactions. Close cooperation at the local level with BLM, FS, SCS, and ranchers have, and are, providing an effective transfer of research information.

i. Plans:

Total biomass recovery of 4-year *Kochia p.* potted in situ will be initiated in 1979 for evaluating clipping influence on CHO and nutrient cycle. A 3-year study to determine big sagebrush subspecies site relations (particularly essential oils, but also watershed characteristics, soils, and plants) will start in 1979. A food habit and home range study of desert sheep, wild horses, cattle, deer, and antelope started in fall, 1978 and will continue through 1982. Additional precipitation catchments will be constructed in 1979 in two off-station locations. Studies will be initiated to define the minimum requirements for successful prescribed burning of sagebrush range. The work will continue

to contribute to the supplemental and grazing management programs and that of artificial breeding studies conducted at this location.

j. Opportunities and Needs:

There is a need for recognition and support by upper echelon SEA-AR that the Squaw Butte Experiment Station is a viable and contributing part of their program. There is also a need to add to the staff a soil scientist, a range agronomist, and an animal scientist and to increase supporting funds.

5. Kimberly, ID - (Range Management - Animal Nutrition)

a. Mission: Develop soil and forage management practices to improve sources of magnesium, phosphorus, zinc, selenium, and related essential minerals for increased production of range animals.

General Service Area:

Rangelands of Western United States

Headquarters - Kimberly, ID

b. Land Resource Region and Area (Austin, 1972):

Northwestern Wheat and Range Region (B)
Snake River Plains (11)
Land Use: 70% in ranching
Elevation: 2,000-5,000 feet

c. Climate (Average):

Precipitation: 7-13 inches, June maximum
Temperature: 41-52° F
Frost-free period: 90-170 days
Soil: Calcisols and brown soils, sierozems

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Sagebrush-Wheatgrass (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silky lupine
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbush
Sitanion spp., squirreltail

g. Objectives:

Develop soil, forage, and pasture management practices to improve the dietary sources of magnesium, phosphorus, zinc, and related essential minerals for animals. Provide quantitative data on seasonal forage quality and more accurate forecasts of outbreaks of such livestock nutritional disorders as grass tetany and zinc deficiency. Provide a basis for a programmed mineral supplementation of livestock.

Provide quantitative data on seasonal forage quality and more accurate forecasts of such nutritional disorders as grass tetany to form a basis for mineral supplementation or soil fertilization.

h. Status:

Developed a moderate understanding of the grass tetany problem, and identified a number of treatment or preventive alternatives. Identified a significant growing animal response to zinc supplementation when forage levels are less than 110 ppm zinc; this occurs when cattle are on cured grass pastures which do not contain forbs.

i. Plans:

Conduct studies on animal response to selenium supplementation in marginal selenium areas and to the effects of silica on forage digestibility.

The effects of soil fertility, moisture, light, temperature, and forage species on the concentration of Mg, Ca, P, Zn, and other minerals in the forage will be investigated.

Factors affecting the concentration in forage of organic acids, silica, associated soil, and other materials that alter the digestibility and nutritional function of essential minerals will be characterized. Forage quality as related to species, physiological maturity, soils and their fertility, or other environmental parameters will be evaluated by direct chemical, in vitro assay, or by grazing animals.

j. Opportunities and Needs:

Continued opportunity to interact with state and federal scientists will promote the identification, investigation, and problem solving of multidisciplinary mineral nutrition problems on range and pasture lands.

6. Dubois, ID - (Range Management - Sheep Production)

a. Mission: To improve forage for sheep compatible with other uses.

b. Land Resource Region and Area (Austin, 1972):

Northwestern Wheat and Range Region (B)
Snake River Plains (11)
Land Use: 70% in ranching
Elevation: 2,000-5,500 feet

c. Climate (Average):

Precipitation: 7-13 inches, June maximum
Temperature: 41-52° F
Frost-free period: 90-170 days
Soil: Calcisols and brown soils, sierozems

d. Ecoregion (Forest Service, 1972):

Intermountain Sagebrush (3130)
Sagebrush-Wheatgrass (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

<u>Artemisia arbuscula</u>, low sagebrush
<u>Balsamorrhiza sagittata</u>, arrowleaf balsamroot
<u>Festuca idahoensis</u>, Idaho fescue
<u>Lupinus sericeus</u>, silky lupine
<u>Oryzopsis hymenoides</u>, Indian ricegrass
<u>Poa sandbergii</u>, Sandberg bluegrass
<u>Sitanion</u> spp., squirreltail

g. <u>Objectives</u>:

1. Improve the efficiency of lamb and wool production of range sheep.

2. Determine the impact of new livestock-forage production technologies on major ecosystems of the intermountain region and evaluate the biology and economics of the technology.

h. <u>Status</u>:

Progress has been made to increase efficiency of sheep production on rangelands in terms of breeding, lambing, and in increasing pounds of lamb.

The range management program was initiated in 1977 in relation to sheep production. Besides working in the sagebrush types, 40% of the research effort is devoted to Subalpine Summer Range located in the Centennial Mountains, Montana. The range includes tall forb, mountain grasslands, dry and wet meadows, sagebrush, and timber types. Improvement of heavily infested <u>Wyethia</u> areas is needed. <u>Geranium viscusissimum</u> is generally reducing forage production in the tall forb type. Specific information is lacking on succession, especially in the tall forb type. The range management and animal research programs are closely linked and are mutually supportive. Research results from both programs are applicable to the general area.

i. <u>Opportunities and Needs</u>:

Opportunities exist in the areas of increasing twinning rate of ewes, eliminating the nonbreeding season of ewes and reducing feed costs in the wintering period by increased efficiency of mechanization. Another range scientist with a soil background and a wildlife biologist are needed on the project to increase the comprehensive scope of the research program.

7. Boise, ID - (Watershed and Hydrology)

a. Mission: To develop models for the hydrologic processes operating on a rangeland watershed and combine them into comprehensive models for predicting the influence of alternate rangeland management practices on watershed soil and water resources.

Headquarters (also Boise Front) - Boise, ID

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (B)
Upper Snake River Land Plains and Hills (10)
Land Use: Range livestock production and grazing
Elevation: 3,000-6,500 feet

c. Climate (Average):

Precipitation: 10-40 inches, summer drought
Temperature: 40-45° F
Frost-free period: 90-110 days
Soil: Aridisols

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Sagebrush-Wheatgrass (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silky lupine
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Sitanion spp., squirreltail

b. Land Resource Region and Area (Austin, 1972):

Western Range and Irrigated Region (D)
Owyhee High Plateau (25)
Land Use: Range livestock production and grazing
Elevation: 3,600-7,500 feet

c. Climate (Average):

Precipitation: 10-45 inches, fall, winter, spring, summer drought
Temperature: 39-45° F
Frost-free period: 90-110 days
Soil: Primarily aridisols, mollisols

d. Ecoregion (Bailey, 1978):

Intermountain Sagebrush (3130)
Sagebrush-Wheatgrass (3131)

e. Ecosystem (Forest Service, 1972):

Sagebrush

f. Potential Natural Vegetation and Major Plant Species (Kuchler, 1964):

Sagebrush Steppe:

Agropyron spicatum, bluebunch wheatgrass
Artemisia tridentata, big sagebrush

Others:

Artemisia arbuscula, low sagebrush
Balsamorrhiza sagittata, arrowleaf balsamroot
Festuca idahoensis, Idaho fescue
Lupinus sericeus, silky lupine
Oryzopsis hymenoides, Indian ricegrass
Poa sandbergii, Sandberg bluegrass
Purshia tridentata, antelope bitterbrush
Sitanion spp., squirreltail

g. Objectives:

1. Quantify and evaluate the effects of rangeland management practices on the watershed processes of infiltration, soil water storage and use, groundwater recharge, runoff rates and amounts, erosion, and sediment yield.

2. Model and evaluate the effects of rangeland management practices on water quality.

3. Investigate and field test management practices for manipulating rangeland snow storage, snowmelt, and runoff to provide additional on-site soil storage and off-site water supply.

4. Develop predictive models for rangeland hydrology and productivity for use by rangeland resource planners and managers.

h. Status:

1. Watershed data base of precipitation, soil moisture, evaporation, ET, runoff rates and amounts, sediment yield, forage yields, water quality, frost, snow accumulations, and associated weather data are being utilized for development and testing of rangeland hydrologic prediction models.

2. Water quality, runoff, vegetation, and sediment data are being used to evaluate deferred and rest-rotation grazing systems.

3. Evaluation is underway of a snow fence for modifying a rangeland accumulation site and potential modulation of runoff amounts and timing.

4. Research is underway on the effect of vegetation cover on erosion and sediment yield.

i. Plans:

Initiate forage yield modeling. Continue data collection and analysis of hydrologic and vegetation factors influenced by a rest-rotation management system. Continue testing of erosion and sediment yield models, a water quality prediction model, and ET and infiltration process models. Develop a comprehensive watershed model for evaluating the impact of management practices on rangeland soil, water, and vegetation resources. Adapt these models for use by resource managers for environmental studies.

j. Opportunities and Needs:

A pressing need of this project is for additional support personnel in the areas of range science and range modeling.

B. Research Teams

Range research in the Northwest region is presently being conducted in five major subject areas by teams at six locations as enumerated in Appendix I. These teams and locations are:

Teams	Research Areas	Locations
1	Forage Improvement - Plant Breeding	Logan, UT
2	Poisonous Plants - Control, Ecology, and Effects on Animals	Logan, UT
3	Range Management, Brush and Weed Control, Reseeding, Fertilization, and Grazing Management	Reno, NV Burns, OR Kimberly, ID
4	Range Management - Rangeland Sheep Production	Dubois, ID
5	Watershed and Hydrology	Boise, ID

Through cooperative efforts among research locations in AR and with various state agricultural experiment stations, universities, and other agencies, significant research progress and accomplishments are being made in the range effort. Much more needed information could be gained with additional funding and staffing of these teams.

V. Research Gaps

Multidisciplinary research on rangelands is now being conducted by the enumerated research teams in the Northwest region. Much of this research is being carried on cooperatively with expertise in many disciplines coming from universities and other agencies. Since the research is complex and of long-term nature, additional staffing would increase effectiveness of the AR projects in solving pressing problems on western rangelands.

The forage improvement and poisonous plants teams input specialized information from their research, which is important for the overall range management effort. The Poisonous Plant Laboratory at Logan could be more effective in its range management role with increased staffing including a range scientist to develop systems of range management around control of poisonous plants. More funding for evaluating plant materials with grazing animals and for improved means of maintaining, increasing, and distributing improved varieties would increase effectiveness of the forage improvement effort in this region.

Teams in general range management research, both in relation to cattle and sheep production, could be strengthened and made more effective by additional staffing in many disciplines and by continuing close cooperation with other AR teams and personnel from universities.

The Watershed and Hydrology team was recently strengthened by the addition of a range scientist to lead range management research in relation to watershed and also to take responsibility for the AR range modeling effort. Range modeling and remote sensing are two important research activities that could be of great benefit to the overall range research program, and should be considered as high priority items for increased funding and staffing.

VI. References

Anonymous. 1966. Water and related land resources, Humboldt River Basin, Nevada - Basinwide Report, Report No. 12. Economic Research Service, Forest Service, Soil Conservation Service, and Max C. Fleischmann, College of Agriculture, University of Nevada, Reno. 120 p. and maps.

Austin, M. E. 1972. Land resource regions and major land resource areas of the United States. USDA Agricultural Handbook 296, 82 p.

Bailey, R. G. 1978. Ecoregions of the United States. Forest Service, USDA. 77 p.

Forest Service. 1972. The nation's range resources--a forest-range environmental study (FRES). USDA Forest Resource Report 19, 147 p.

Kuchler, A. W. 1964. Potential natural vegetation of the conterminous United States. Amer. Geogr. Soc. Spec. Pub. 36. 116 p.

Appendix A. Rangeland types, areas, conditions, and stocking in the Northwest Region[1/]

Ecosystem	Area						Condition (US)				Grazed (US)	Stocking Rate (US)	Total Stocking[2/]	
	NV	UT	ID	OR	WA	Total	Good	Fair	Poor	Very Poor			Present	Potential
	-------1,000,000 acres-------						--------------%--------------				%	AUM/a	---1,000 AUM's----	
Sagebrush	34.7	10.4	20.4	15.0	4.1	84.6	12.3	36.1	35.0	16.6	89	0.182	12,200	50,700
Desert Shrub	19.5	12.1	0.9	3.5	0.0	36.0	17.4	36.4	31.5	14.7	70	0.041	1,000	3,600
Chaparral-mountain shrub	1.2	1.0	0.2	0.1	0.0	2.5	11.8	24.0	37.9	26.3	95	0.125	300	1,300
Pinyon-juniper	4.7	9.0	0.4	2.4	0.0	16.5	9.1	28.6	44.4	17.9	88	0.073	1,100	4,200
Mountain Grasslands	0.3	0.8	0.7	3.0	2.8	7.6	17.5	36.2	31.2	15.1	97	0.319	2,400	8,200
Mountain Meadows	0.2	<0.1	0.5	0.2	0.1	1.0	32.4	38.8	21.1	7.7	79	0.613	500	1,300
Desert Grasslands	0.0	1.2	0.0	0.0	0.0	1.2	8.4	24.7	50.5	16.4	93	0.091	100	400
Alpine	0.0	0.5	0.6	0.8	1.0	2.9	42.8	27.1	28.7	1.4	70	0.045	100	200
Douglas Fir	<0.1	0.8	6.9	10.1	7.7	25.5	--	--	--	--	52	0.049	650	1,300
Ponderosa Pine	0.1	0.5	2.0	5.6	2.3	10.5	--	--	--	--	74	0.059	460	920
Western White Pine	<0.1	0.0	0.3	0.1	0.1	0.5	--	--	--	--	48	0.234	60	120
Fir-spruce	0.2	1.5	4.6	3.8	4.1	14.2	--	--	--	--	51	0.028	200	400
Hemlock-sitka spruce	<0.1	0.0	1.2	1.1	4.4	6.7	--	--	--	--	0	0.000	0	0
Lodgepole Pine	0.1	0.7	3.7	2.2	0.9	7.6	--	--	--	--	56	0.011	50	100
Hardwoods	0.3	2.0	0.6	2.5	2.2	7.6	--	--	--	--	56	0.059	250	500
Redwood	0.0	0.0	0.0	<0.1	0.0	0.0	--	--	--	--	55	0.063	0	0
Larch	0.0	0.0	0.8	0.1	0.6	1.5	--	--	--	--	41	0.147	90	180
Wet Grasslands	0.1	0.3	<0.1	0.0	<0.1	0.4	17.0	27.6	20.7	34.7	79	0.663	210	1,030
Desert	2.1	4.7	0.5	0.0	0.0	7.3	76.6	11.5	6.5	5.4	45	0.001	3	7
TOTAL	63.5	45.5	44.3	50.5	30.3	234.1							19,673	74,457

1/ Partially obtained from and based on, "An Assessment of the forest and Range Land Situation in the United States," (Forest Service FS-345, 1980).

2/ Present stocking = (total area) x (% grazed) x (stocking rate). Potential stocking was calculated by assuming that good, fair, poor, and very poor conditions produced 80, 50, 30, and 10%, respectively, of potential. Based on the ecosystems with condition data, we assumed that the potential stocking for the remaining ecosystems could be doubled.

Appendix A-1. Northwest Region - Shaded area denotes Intermountain Sagebrush Ecoregion

Legend - Approximate area of Intermountain Sagebrush Ecosystem (3130) and proportionate extent of sections (area given in acres and percent to the nearest tenth) (Bailey, 1976).

Province and Section	Area	Extent in Province	Extent in U.S.
	acres (000's)	%	%
3130 - Intermountain Sagebrush	130,176		6.2
3131 - Sagebrush-Wheatgrass	57,472	44.1	2.8
3132 - Lahontan Saltbush-Greasewood	21,312	16.4	1.0
3133 - Great Basin Sagebrush	30,016	23.1	1.4
3134 - Bonneville Saltbush-Greasewood	14,208	10.9	0.7
3135 - Ponderosa Shrub Forest	7,168	5.5	0.3

Appendix A-2. Acreage and percentage of present annual forage plant production classes for each vegetal type and site, Humboldt River Basin.

Vegetal type and site	Forage production classes (acres) Fairly high	Medium	Low	Total (acres)	Percent of basin area
1. Rabbitbrush-greasewood-grass: saline bottomlands	7,700 (< 1%)	55,300 (7%)	741,320 (92%)	804,320)	7.5
(range seeding)	6,600 (78%)	1,900 (22%)	---	8,500)	
2. Semi-playa-greasewood-pickleweed, alkali bottomlands	---	---	94,100	94,100	0.9
3. Salt cedar-greasewood-saltgrass; wet saline bottomlands	---	---	9,200	9,200	0.1
4. Salt cedar-greasewood: alkali flats	---	---	35,700	35,700	0.3
5. Meadow grasses-forbs-sedges: semi-wet meadows	47,200 (33%)	31,200 (22%)	65,700 (46%)	144,100	0.3
6. Big sagebrush-grass; upland benches and terraces	44,835 (1%)	473,770 (11%)	3,628,950 (88%)	4,147,555)	40.1
(range seeding)	198,965 (89%)	24,060 (11%)	---	223,025	---
7. Shadscale-grass; droughty desert uplands	1,200 (<1%)	63,600 (4%)	1,499,800 (96%)	1,564,600	14.3
8. Winterfat-budsage-big sage-grass; silty desert flats	---	---	15,600	15,600	0.2
9. Low sagebrush-grass; claypan benches	43,600 (8%)	151,900 (27%)	365,900 (65%)	561,400	5.1
10. Browse-aspen-grass; intermediate mountain slopes	83,000 (6%)	367,100 (28%)	854,600 (66%)	1,304,700	12.0
11. Pinyon-juniper-grass; shallow, stony slopes	22,900 (4%)	112,300 (20%)	430,500 (76%)	565,700	5.2
12. Browse-aspen-conifer-grass; steep mountain slopes and basins	60,000 (9%)	287,000 (43%)	314,800 (48%)	661,800	6.1
SUBTOTAL	516,000	1,568,130	8,056,170	10,140,300	(92.1)

Appendix B. Livestock and animal units in the Northwest Region, 1977[1/]

Class of livestock	Number NV	UT	ID	OR	WA	Total	Animal units[2/] NV	UT	ID	OR	WA	Total
	1,000 head						1,000 units					
Beef cows	298	335	608	599	355	2,195	298	335	608	599	355	2,195
Replacement heifers	47	53	92	97	97	386	33	37	64	68	68	270
Bulls	15	15	32	34	18	114	19	19	40	42	22	142
Calves under 500 lb	153	190	426	349	201	1,319	61	76	170	140	80	527
Total Cattle	513	593	1,158	1,079	671	4,014	411	467	882	849	525	3,134
Ewes	100	475	420	247	50	1,292	20	95	84	49	10	258
Wethers and rams	3	14	9	11	4	41	1	4	2	3	1	11
Lambs	17	71	61	52	10	211	2	7	6	5	1	21
Total sheep	120	560	490	310	64	1,544	23	106	92	57	12	290
Total							434	573	974	906	537	3,424

1/ From 1977 Agricultural Statistics.

2/ 1 heifer = 0.7 AU; 1 bull = 1.25 AU; 1 calf = 0.4 AU; 1 ewe = 0.2 AU; 1 wether or ram = 0.25 AU; 1 lamb = 0.1 AU.

Appendix C. Estimates of the number of wildlife in the Northwest Region

	Nevada	Utah	Idaho[1/]	Washington
Deer	112,740	275,000	45,300	49,000
Antelope	6,000	1,000	4,000	
Bighorn sheep	4,000		350	400
Elk	400	22,500	400	50,000
Moose		400		
Mountain goats				9,000
Wild horses	35,000		563	
Black bear			230	
Cougar			45	

1/ Estimates for Idaho are for the Boise and Vale BLM districts, only. No estimates for Oregon were available.

Appendix D. Some potential species for seeding rangelands in the Northwest Region

Grasses	Grasses
Agropypron cristatum, fairway wheatgrass	Sporobolus airoides, alkali sacaton
A. dasystachyum, thickspike wheatgrass	S. cryptandrus, sand dropseed
A. desortorum, crested wheatgrass	
A. inerme, beardless wheatgrass	**Forbs**
A. intermedium, intermediate wheatgrass	
A. riparium, streambank wheatgrass	Astragalus cicer, cicer milk vetch
A. sibericum, Siberian wheatgrass	Coronilla varia, crown vetch
A. smithii, western wheatgrass	Lotus corniculatus, birdsfoot trefoil
A. trachycaulum, slender wheatgrass	L. tenuis, narrowleaf trefoil
A. trichophorum, pubescent wheatgrass	L. uliginosus, big trefoil
Bromus biebersteinii, meadow brome	Medicago falcatus, sickle alfalfa
B. inermis, smooth brome	M. sativa, alfalfa
B. marginatus, mountain brome	Melilotus spp., sweetclover
Dactylis glomerata, orchardgrass	Onobrychis viciaefolia, sainfoin
Elymus cinereus, basin wildrye	Penstemon strictus, Rocky Mountain penstemon
E. junceus, Russian wildrye	Trifolium repens, white clover
E. triticoides creeping wildrye	Vicia enuifolia, bramble vetch
Festuca arundinacea, tall fescue	
F. idahoensis, Idaho fescue	**Shrubs**
F. ovina var. duriuscula, hard fescue	
F. rubra, red fescue	Atriplex canescens, fourwing saltbush
Lolium perenne, perennial ryegrass	Ceanothus prostratus, squaw-carpet
Oryzopsis hymenoides, Indian ricegrass	Ceratoides lanata, winterfat
Phlaris arundinacea, reed canarygrass	Cercocarpus montanus, mountain mahogany
Poa ampla, big bluegrass	Fallugia paradoxa, Apache plume
P. cambyi, camby bluegrass	Purshia tridentata, antelope bitterbrush
P. sandbergii, Sandberg bluegrass	

Appendix E. Information available and the need for research for various categories of range science based on a survey of scientist working in the Northwest Region in 1978.

Item	Category	Research information available 1/		Research needs 1/	
I.	Inventory and Classification		2.4		3.1
	A. Census				
	1. Vegetation	2.5		2.8	
	2. Forage utilization	2.4		3.1	
	3. Soil stability	2.6		2.7	
	4. Animal populations	2.5		3.0	
	5. Animal movements	2.4		2.9	
	6. Weather	2.4		3.1	
	B. Determination of Range Trends	2.3		3.2	
	C. Site Potential	2.0		3.6	
	D. Assessment of Annual Forage Crops	2.3		3.0	
	E. Land Use	2.2		3.1	
II.	Improved Plants		1.7		3.9
	A. Germplasm				
	1. Collection	2.1		4.1	
	2. Preservation	2.1		3.9	
	3. Species relationships	2.0		3.6	
	B. Evaluate Adaptability	2.0		3.9	
	C. Breeding				
	1. Stress	1.8		4.5	
	2. Photosynthetic efficiency	1.8		3.5	
	3. Quality and quantity	1.9		4.0	
	4. N-fixation	2.0		3.4	
	5. Disease and insect resistance	1.8		3.6	
	6. Water use efficiency	1.8		4.1	
	D. Seed Production	1.9		3.8	
III	Revegetation		2.2		3.8
	A. Availability of Plant Materials	2.2		4.0	
	B. Germination	2.3		3.4	
	C. Seedling Establishment	2.2		4.1	
	D. Methods	2.6		3.4	
	E. Grazing Adaptability	2.2		3.9	
IV.	Ecology, Damage, and Control of Pests		2.1		3.0
	A. Unwanted Plants (noxious, poisonous)	2.5		3.7	
	B. Diseases	1.9		2.6	
	C. Nematodes	1.9		2.4	
	D. Insects	2.0		3.3	
	E. Rodents	2.0		3.3	
	F. Rabbits	2.3		2.6	
V.	Other Manipultive Treatments		2.4		2.9
	A. Fertilization	2.6		2.6	
	B. Mechanical Treatments (ripping, furrowing, etc.)	2.5		2.4	
	C. Moisture Conservation	2.1		3.4	
	D. Development of Animal Water	2.4		2.4	
	E. Burning	2.2		3.5	
VI	Complementary Pastures		2.3		3.3
	A. Seasonality	2.3		3.2	
	B. Quantity and Quality	2.3		3.3	
VII.	Grazing Systems		2.1		3.7
	A. Proper Utilization	2.3		3.5	
	B. Stocking Rate	2.3		3.3	
	C. Time of Grazing	2.1		3.5	
	D. Native Range Alone	2.2		3.5	
	E. Native Range plus Complementary Pastures	2.0		3.9	
	F. Native Range plus Manipulated Range	2.0		4.0	
	G. Manipulated Range	1.9		4.1	

Appendix E. (Continued)

Item	Category	Research information available 1/		Research needs 1/	
VIII.	Effects of Practices III-VII		2.1		4.0
	A. Water Quality and Quantity	1.9		3.9	
	B. Moisture Conservation	2.1		3.9	
	C. Erosion and Sedimentation	2.1		3.9	
	D. Range Ecology	2.0		4.6	
	E. Animal Performance and Behavior	2.2		3.8	
IX.	Livestock		2.3		3.1
	A. Diet and Nutrition	2.4		3.1	
	B. Performance	2.2		3.5	
	C. Trampling	2.3		2.4	
	D. Behavior	2.3		3.1	
	E. Distribution	2.3		3.2	
X.	Wildlife		2.1		3.4
	A. Population	2.1		3.2	
	B. Diet	2.1		3.4	
	C. Habit	2.1		3.0	
	D. Distribution	2.1		3.1	
	E. Wildlife-Livestock Relations	2.0		4.0	
XI.	Basic Range Research		2.0		4.2
	A. Plant	2.0		4.2	
	B. Plant-Environment Interactions	2.0		4.2	
	C. Water Use by Plants	2.0		4.6	
	D. Plant-Animal Interactions	1.9		4.0	
	E. N-fixation	2.0		4.1	
XII.	Models				
	A. Analysis		1.8		3.3
	1. Prediction	2.1		3.3	
	2. Identification	2.0		3.3	
	3. Detection of research needs	1.9		3.5	
	B. Synthesis or Simulation	2.0		3.3	
	C. Management	2.0		3.4	

1/ Research available: Adequate = 3; inadequate = 2; none = 1.
Research need: High = 5; high-medium = 4; medium = 3; medium-low = 2; low = 1.

Appendix F. Northwest (SY's) Ecosystems[1/]

Location and scientist	C	G	I	J	L	M
Logan						
Asay	0.65			0.20	0.05	0.10
Dewey	1.00					
Gomm	1.00					
Johnson	0.65			0.20	0.05	0.10
Rumbaugh	0.50			0.25	0.10	0.15
Cronin	0.20		0.20	0.20	0.20	0.20
James	0.30		0.15	0.20	0.15	0.20
Johnson	0.15		0.15			
Keeler	0.15		0.15			
Olson	0.20					
Williams	0.30		0.15	0.20	0.15	0.20
Reno						
Eckert	0.70		0.10		0.20	
Evans	0.60		0.10	0.20		
Young	0.40		0.15	0.30		
Burns						
Sneva	0.80				0.20	
Kimberly						
Mayland	0.63					0.07
Dubois						
Doyle	0.70					0.30
Ercanbrack	0.70					0.30
Gates	0.70					0.30
Hulet	0.70					0.30
Murray	0.70					0.30
Stellflug	0.70					0.30
Boise						
Brackensiek	0.80	0.05				0.15
Cooley	0.80	0.05				0.15
Hanson	0.80	0.05				0.15
Huber	0.80	0.05				0.15
Johnson	0.80	0.05				0.15
Stephenson	0.80	0.05				0.15
Wight	0.80	0.05				0.15
Total	18.03	0.35	1.15	1.75	1.10	3.87
					GRAND TOTAL	26.50[2/]

[1/] C = Sagebrush; G = Desert grasslands; I = Desert shrub; J = Pinyon-juniper; L = Mountain meadows; M = Mountain grasslands

[2/] 0.25 SY devoted to research on California annual rangelands (Southwest Region). Evans spends 10% of his time and Young 15% of his time on research activities in this ecosystem.

Appendix G. Northwest (SY's)

Location and scientist	NRP[1/] 20110	20100	20160	20170	20280	20380	20470	20780	20800	20810
Logan										
Asay	0.80(P)			0.20(R)						
Dewey	0.70(P)	0.20(P)	0.10(R)							
Gomm	1.00(P)									
Johnson	0.30(R)			0.70(P)						
Rumbaugh	1.00(P)									
Cronin	0.10(R)				0.90(P)					
James							1.00(P)			
Johnson							0.30(P)			
Keeler							0.30(P)			
Olson							0.20(P)			
Williams					1.00(P)					
Reno										
Eckert	0.80(P)				0.20(R)					
Evans	0.40(R)				0.60(P)					
Young	0.20(R)				0.80(P)					
Burns										
Sneva	0.90(P)				0.10(R)					
Kimberly										
Mayland								0.70(P)		
Dubois										
Doyle						1.00(P)				
Ercanbrack						1.00(P)				
Gates						1.00(P)				
Hulet						1.00(P)				
Murray	1.00(P)									
Stellflug						1.00(P)				
Boise										
Brackensiek									0.10(R)	0.90(P)
Cooley										1.00(P)
Hanson									0.20(R)	0.80(P)
Huber										1.00(P)
Johnson									0.70(P)	0.30(R)
Stephenson									0.20(R)	0.80(P)
Wight										1.00(P)
Total	7.20	0.20	0.10	0.90	3.60	5.00	1.80	0.70	1.20	5.80
									Grand Total	26.50

[1/] P = primary; R = related. See below for key to NRP's.

Titles of National Research Programs (NRP)

20110-Improved vetetation and management practices for range.
20100-Breeding and production - forage crops for hay, pastures, and other uses including turf.
20160-Introduction, classification, maintenance, evaluation, and documentation of plant germplasm.
20170-Physiological and biochemical technology to improve crop production.
20280-Weed control technology for protecting crops, grazing lands, aquatic sites, and noncropland.
20380-Production of sheep and other animals.
20470-Toxicology of chemicals and poisonous plants.
20780-Utilize, manage, and conserve soil fertility for increased production and nutritional quality of plants and animals.
20800-Control of water erosion, wind erosion, and sedimentation.
20810-Conserve and manage agricultural water resources.

Appendix H. Northwest (SY's) Range Research[1/]

Location and scientist	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
<u>Logan</u>												
Asay		0.85	0.05								0.10	
Dewey		1.00										
Gomm		1.00										
Johnson		0.45	0.10								0.45	
Rumbaugh		1.00										
Cronin	0.05			0.65	0.20		0.05					0.05
James				1.00								
Johnson				0.30								
Keeler				0.30								
Olson				0.20								
Williams				0.20							0.80	
<u>Reno</u>												
Eckert	0.05		0.20	0.10	0.05		0.40	0.20				
Evans	0.10		0.20	0.35	0.05		0.05			0.05	0.20	
Young	0.05	0.05	0.50	0.25	0.05					0.05	0.05	
<u>Burns</u>												
Sneva	0.05	0.10	0.05		0.20			0.10	0.10	0.20	0.15	0.05
<u>Kimberly</u>												
Mayland	0.04								0.52		0.14	
<u>Dubois</u>												
Doyle									1.00			
Ercanbrack									1.00			
Gates				1.00								
Hulet									1.00			
Murray	0.15	0.10	0.05		0.25		0.15	0.10	0.10	0.10		
Stellflug									1.00			
<u>Boise</u>												
Brackensiek	0.10	0.05			0.05			0.50			0.05	0.25
Cooley	0.10							0.20				0.70
Hanson	0.10	0.05			0.05			0.50			0.05	0.25
Huber	0.10							0.10				0.80
Johnson	0.10							0.70			0.10	0.10
Stephenson	0.10							0.70			0.10	0.10
Wight	0.10							0.40			0.10	0.40
Total	1.19	4.65	1.15	4.35	0.90	0	0.65	3.50	4.72	0.40	2.29	2.70
										GRAND TOTAL		26.50

[1/] Research Categories:

I = Inventory and classification
II = Improved plants
III = Revegetation
IV = Ecology, damage, and control of pests
V = Other manipulative treatments
VI = Complementary pastures
VII = Grazing systems
VIII = Effects of practices III - VII
IX = Livestock
X = Wildlife
XI = Basic research
XII = Models

Appendix I. Scientists presently assigned to range research teams in the Northwest Region

Forage Improvement - Plant Breeding

Location	Scientists	Discipline	SY's
Logan, UT	Asay	Grass Breeder	1.0
	Dewey	Cytogeneticist	1.0
	Gomm	Range Scientist	1.0
	Johnson	Physiologist	1.0
	Rumbaugh	Legume Breeder	1.0
		Total	5.0

Poisonous Plants - Control, Ecology, and Effects on Animals

Location	Scientists	Discipline	SY's
Logan, UT	Cronin	Plant Physiologist	1.0
	James	Animal Scientist	1.0
	Johnson	Animal Physiologist	0.3
	Keeler	Chemist	0.3
	Olson	Veterinarian	0.2
	Williams	Plant Physiologist	1.0
		Total	3.8

Range Management - Brush and Weed Control, Reseeding, and Grazing Management

Location	Scientists	Discipline	SY's
Reno, NV	Eckert	Range Scientist	1.0
	Evans	Range Scientist	1.0
	Young	Range Scientist	1.0
Burns, OR	Sneva	Range Scientist	1.0
Kimberly, ID	Mayland	Soil Scientist	0.7
		Total	4.7

Range Management - Rangeland Sheep Production

Location	Scientists	Discipline	SY's
Dubois, ID	Doyle	Animal Scientist	1.0
	Ercanbrack	Animal Geneticist	1.0
	Gates	Veterinarian	1.0
	Hulet	Animal Physiologist	1.0
	Murray	Range Scientist	1.0
	Stellflug	Physiologist	1.0
		Total	6.0

Watershed and Hydrology

Location	Scientists	Discipline	SY's
Boise, ID	Brackensiek	Hydraulic Engineer	1.0
	Cooley	Hydrologist	1.0
	Hanson	Agricultural Engineer	1.0
	Huber	Agricultural Hydrologist	1.0
	Johnson	Hydraulic Engineer	1.0
	Stephenson	Geologist	1.0
	Wight	Range Scientist	1.0
		Total	7.0

REPORTS IN THIS SERIES

Evans, R. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Great Basin and Northwest. 1980. SEA-AR range research in the Great Basin and Northwest (Idaho, Nevada, Oregon, Utah, and Washington). Agricultural Research, Science and Education Administration, U.S. Department of Agriculture.

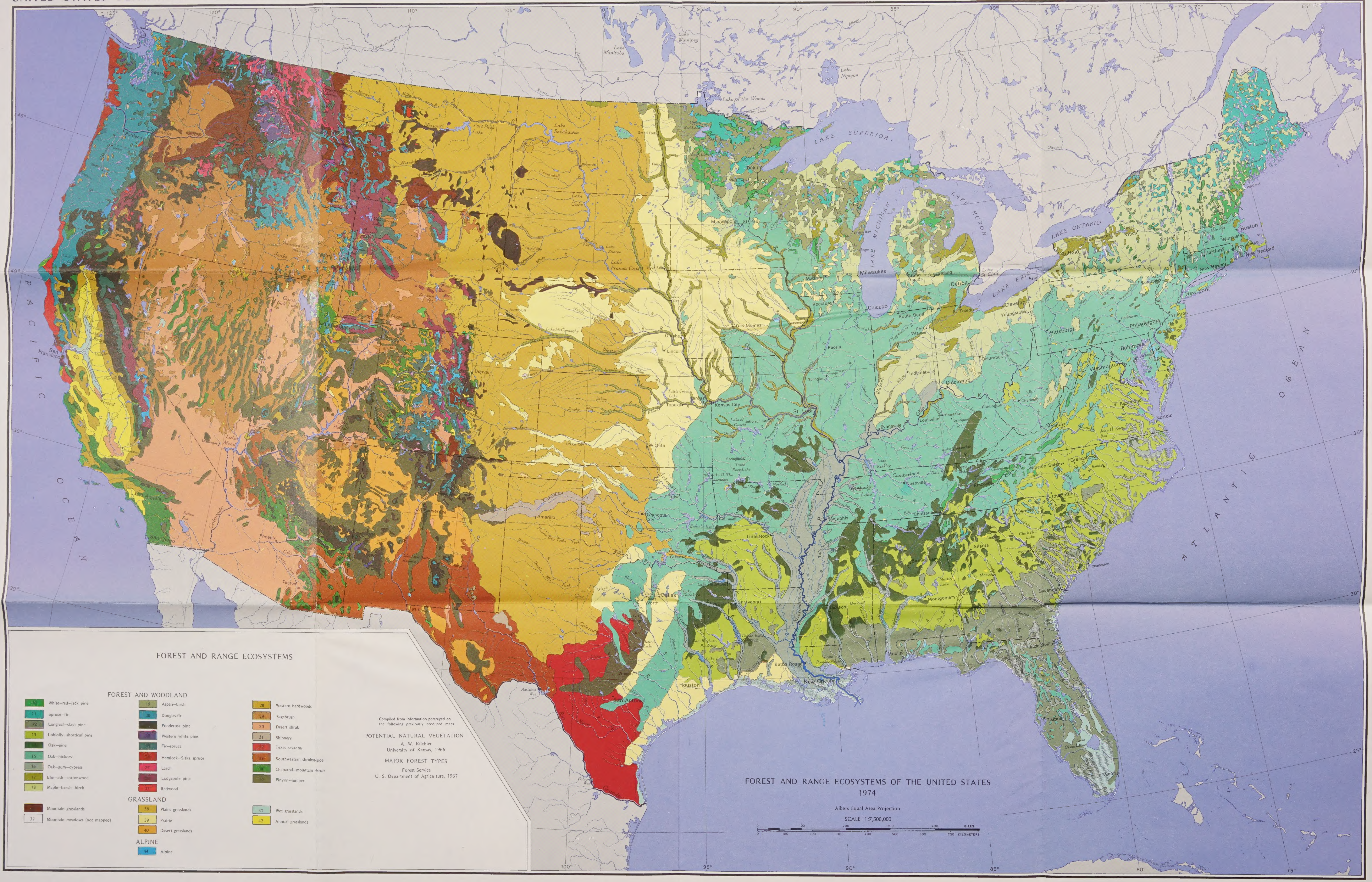
Herbel, C. H., P. L. Sims, W. A. Laycock, R. J. Lorenz, R. A. Evans, K. G. Renard, SEA-AR Rangeland Scientists in the 17 Western States, R. F Barnes, and G. E. Carlson. 1980. Range research, an assessment of current problems and a strategy for the future: A summary of range research by SEA-AR in the 17 western states. Agricultural Research, Science and Education Administration, U. S. Department of Agriculture. 18 pages.

Laycock, W. A., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Central Great Plains. 1980. SEA-AR range research in the Central Great Plains (Colorado, Kansas, Nebraska, and Wyoming). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Lorenz, R. J., J. R. Wight, R. J. Kartchner, C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Northern Great Plains. 1980. SEA-AR range research in the Northern Great Plains (Montana, North Dakota, and South Dakota). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.

Renard, K. G., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southwest. 1980. SEA-AR range research in the Southwest (Arizona, California, and New Mexico). Agricultural Research, Science and Education Administration, U. S. Deparment of Agriculture.

Sims, P. L., C. H. Herbel, R. F Barnes, and SEA-AR Rangeland Scientists in the Southern Great Plains. 1980. SEA-AR range research in the Southern Great Plains (Oklahoma and Texas). Agricultural Research, Science and Education Administration, U. S. Department of Agriculture.


FOREST AND RANGE ECOSYSTEMS OF THE UNITED STATES
1974
Albers Equal Area Projection
SCALE 1:7,500,000
0 100 200 300 400 MILES
0 100 200 300 400 500 600 700 KILOMETERS
FOREST AND RANGE ECOSYSTEMS
FOREST AND WOODLAND
White–red–jack pine
11 Spruce–fir
12 Longleaf–slash pine
13 Loblolly–shortleaf pine
Oak–pine
15 Oak–hickory
16 Oak–gum–cypress
17 Elm–ash–cottonwood
18 Maple–beech–birch
19 Aspen–birch
20 Douglas-fir
Ponderosa pine
Western white pine
Fir–spruce
Hemlock–Sitka spruce
25 Larch
Lodgepole pine
Redwood
28 Western hardwoods
29 Sagebrush
30 Desert shrub
31 Shinnery
Texas savanna
Southwestern shrubsteppe
Chaparral–mountain shrub
Pinyon–juniper
GRASSLAND
Mountain grasslands
37 Mountain meadows (not mapped)
38 Plains grasslands
39 Prairie
40 Desert grasslands
41 Wet grasslands
42 Annual grasslands
ALPINE
44 Alpine
Compiled from information portrayed on the following previously produced maps
POTENTIAL NATURAL VEGETATION
A. W. Küchler
University of Kansas, 1966
MAJOR FOREST TYPES
Forest Service
U. S. Department of Agriculture, 1967
PACIFIC
OCEAN
ATLANTIC
OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE